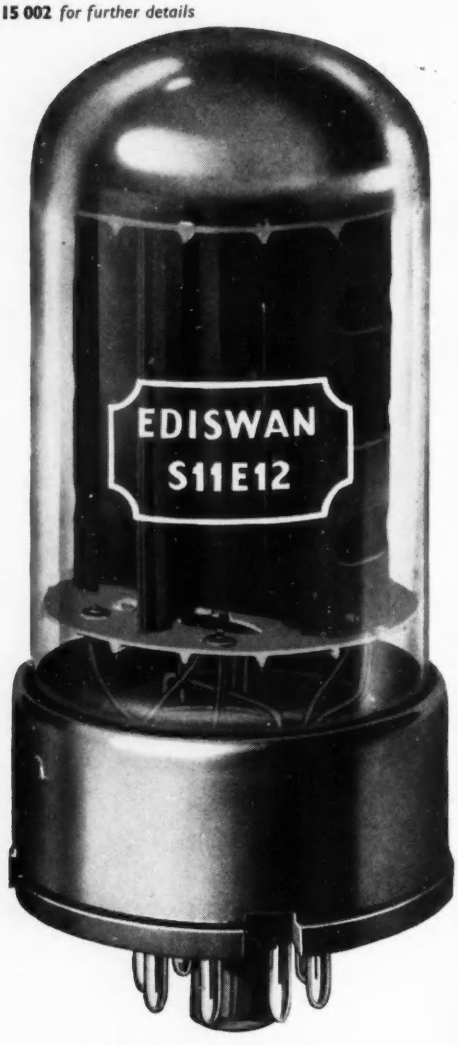
Electronic Engineering

The RACAL TRA.55 60 watt Radio Telephone is gaining rapid acceptance for S.S.B. communication in overseas territories.

EE 15 002 *for further details*



THE EDISWAN S11E12 (CV4060)
Special Quality Beam Tetrode

a newcomer with a first class reference

The S11E12 is the latest addition to the range of Ediswan valves designed specifically for use in series or shunt control circuits. The S11E12 has an international octal base and the important parameters are as follows:

Heater Voltage (volts)	V_h	6.3
Heater Current (amps)	I_h	1.6
Anode Voltage, maximum (volts)	V_a (max)	800
Screen Voltage, maximum (volts)	V_{g2} (max)	300
Mutual Conductance (mA/V)	g_m	13.5
Anode Dissipation (watts)	P_a (max)	28
Cathode Current (mA)	I_k (max)	300

The new valve is specially designed to resist shock and is quality tested at all stages of manufacture to ensure maximum reliability and life expectancy. It is available from stock.

Further information on this and other valves in the CV 4000 range will be gladly sent on request.

CRC 16/9

EDISWAN
INDUSTRIAL VALVES AND CATHODE RAY TUBES
SIEMENS EDISON SWAN LTD
An A.E.I. Company. 155 Charing Cross Road, London, W.C.2
Telephone: GERrard 8660

Vol. 31 No. 381

NOVEMBER, 1959

Electronic Engineering

Incorporating ELECTRONICS, TELEVISION and SHORT WAVE WORLD

Managing Editor: H. G. FOSTER, *M.Sc., M.I.E.E., M.Brit.I.R.E.*

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PUBLISHED MONTHLY on the last Friday of the preceding month by:

MORGAN BROTHERS (PUBLISHERS) LIMITED
at 28, Essex Street, Strand, London, W.C.2.
Telephone: CENtral 6565 Telegrams: 'Lectroning, Estrand, London'
Annual Subscription: Home and Overseas £1.16.0 post free, Canada and U.S.A. $5

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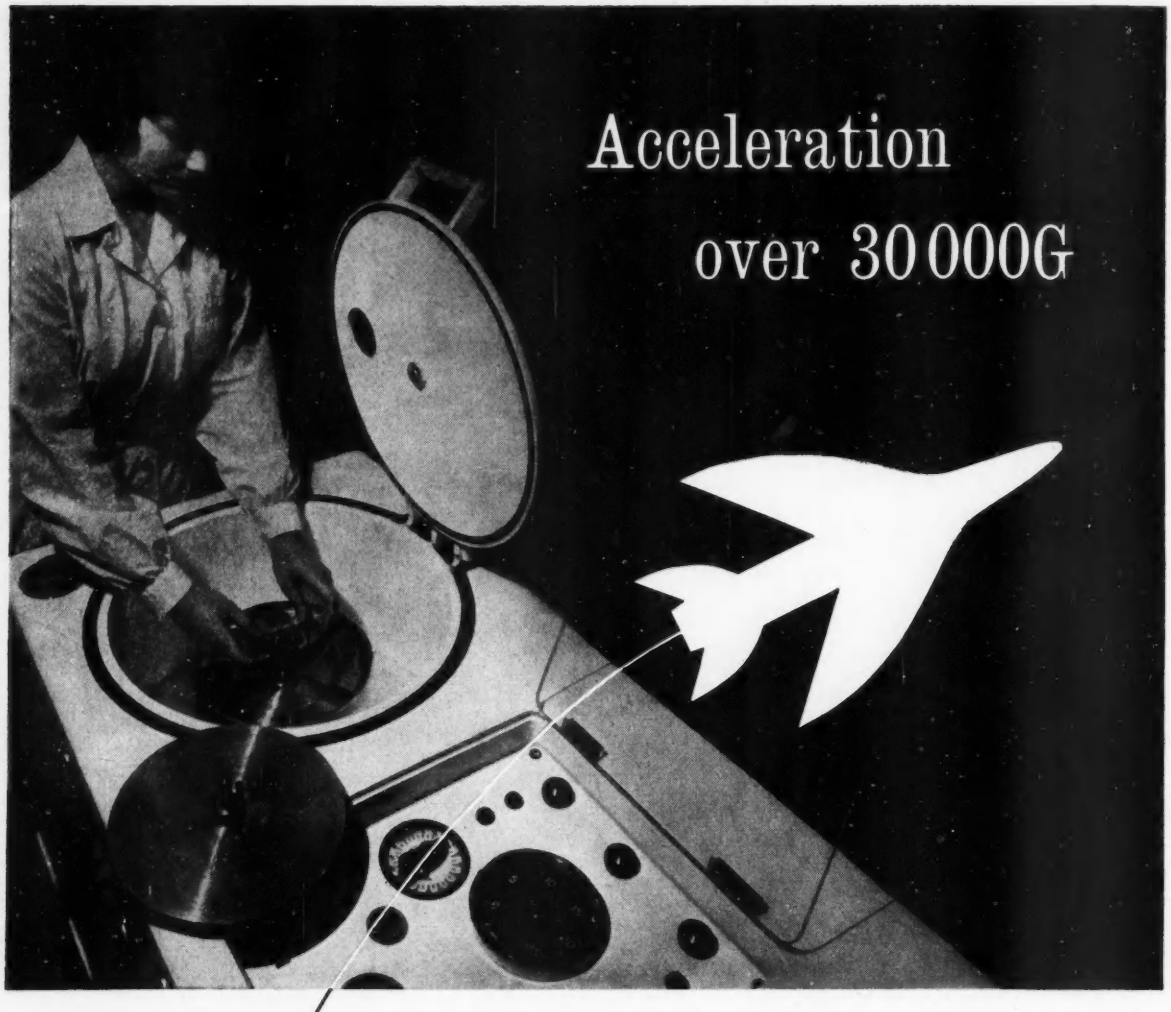


The proved reliability of the Brimar 'T' range of valves has been "built-in" as the result of experience gained from a programme of examination and testing. One of these tests is illustrated. Valves are placed in a rotor inside a chamber which is later evacuated. The rotor is then accelerated at high speed to simulate the effects experienced by super high speed aircraft flying at high altitudes. The information derived from this and other tests on valves for special applications is used to improve manufacturing techniques on commercial types: which makes Brimar the obvious choice when the demand is for a *reliable* valve.

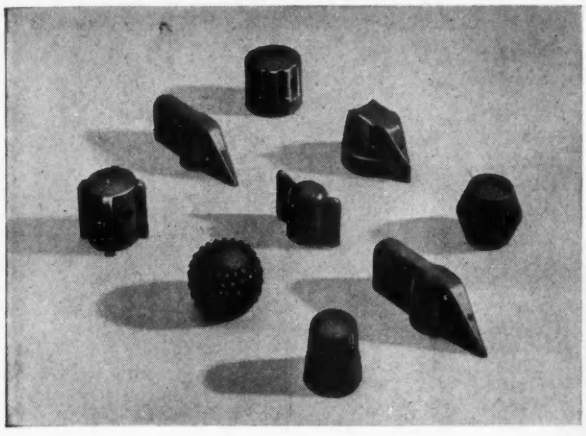
better make it **BRIMAR**

STC COMPONENTS GROUP

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

VALVE DIVISION: FOOTSCRAY · SIDCUP · KENT · FOOTSCRAY 3333

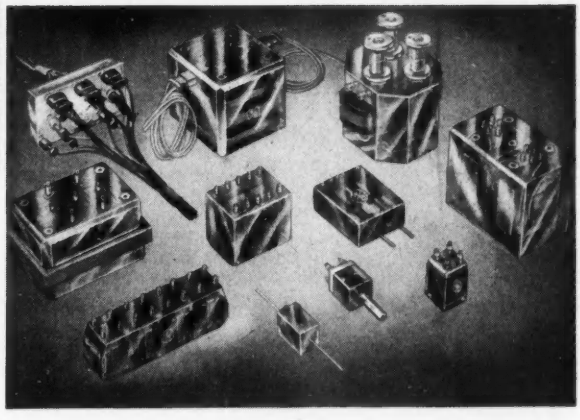


We illustrate examples of our extensive range of knobs moulded in Polythene. This particular series has been developed for the R.A.F. and was designed by us to enable cockpit controls to be recognised by touch.

Also available in Polythene and P.V.C. are waterproof plugs and sockets which were developed for the R.A.F. and have since been extensively adopted by aircraft companies for use in conditions of high humidity.

We are specialists in the design and manufacture of encapsulated components in Epoxy and Polyester resins. Illustrated below are a few typical examples.

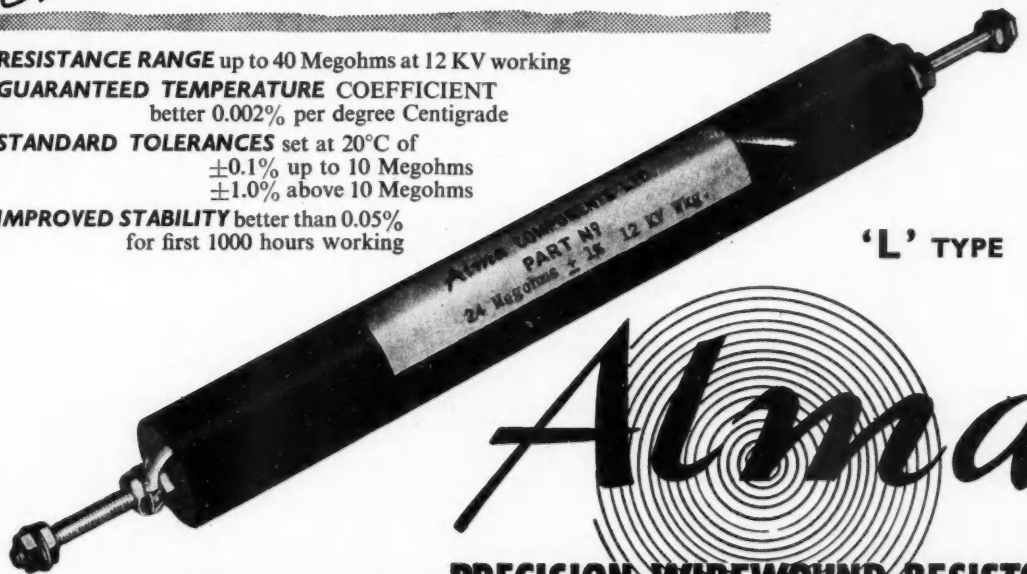
Our technical representative would be pleased to discuss their use for your particular applications.



WHITELEY ELECTRICAL RADIO CO. LTD.
MANSFIELD · NOTTS
TELEPHONE : MANSFIELD 1762/5

NEW HIGH VALUE RANGE OF PRECISION WIREWOUND RESISTORS

- ***RESISTANCE RANGE*** up to 40 Megohms at 12 KV working
- ***GUARANTEED TEMPERATURE*** COEFFICIENT better 0.002% per degree Centigrade
- ***STANDARD TOLERANCES*** set at 20°C of ±0.1% up to 10 Megohms ±1.0% above 10 Megohms
- ***IMPROVED STABILITY*** better than 0.05% for first 1000 hours working



'L' TYPE

Write or phone for details of our wide range of standard or special resistors.

Alma PRECISION WIREWOUND RESISTORS
AID Approved
ARB Approved

Alma COMPONENTS Ltd. 551 HOLLOWAY ROAD, LONDON, N.19 Telephone : ARCHWAY 0014/5

EE 15 006 *for further details*

Trace Assessor Cabinet

The cabinet of this Benson-Lehner "Oscar Model E" Trace Assessor is manufactured by Dormac Ltd., Lymington from Turners "Duraglas"

Photograph by courtesy of Benson-Lehner (G.B.) Ltd.

Made from TURNERS

DURAGLAS Regd.
GLASS FIBRE REINFORCEMENTS

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TURNER BROTHERS ASBESTOS CO LTD ROCHDALE ENGLAND

A MEMBER OF THE TURNER & NEWALL ORGANISATION

TAI63

EE 15 007 *for further details*

new EKCO precision ratemeters

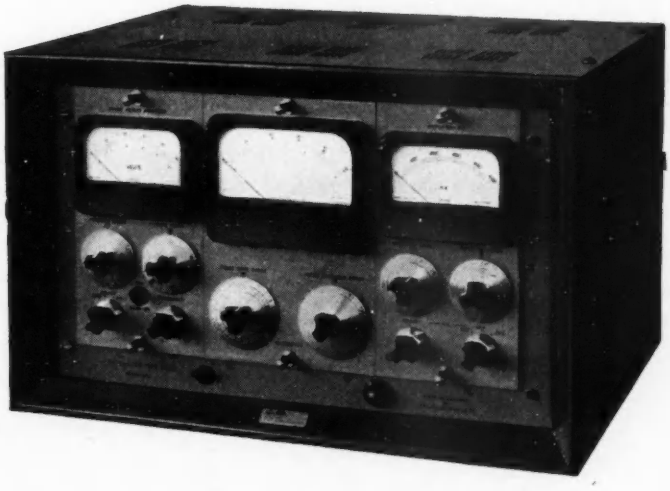
Type N600 & N624 Ratemeters

The Ekco Type N600 Ratemeter is a precision counting ratemeter for use with all forms of radiation counters. It incorporates a stabilised high voltage supply suitable for G-M tubes or scintillation counters, an input amplifier, and a single channel pulse height analyser. With a suitable counter it forms a complete counting equipment, and with a recorder also it forms a complete spectrum analyser. It consists of three plug-in units, each carrying its own meter. These monitor discriminator threshold or gate width, ratemeter output, and HV supply. The gate width is continuously variable and may be set to a fixed value or a fixed percentage of threshold; this latter often gives better resolution of the lower energy peaks.

The Ratemeter N624 is a simplified version of the N600, incorporating a simple discriminator and a single meter to monitor ratemeter output, discriminator threshold or HV supply.

BOTH INSTRUMENTS, TYPE N600 & N624 ARE ON DISPLAY AT THE PHYSICAL SOCIETY EXHIBITION

EKCO STAND 30



SPECIFICATION

Input Sensitivity. 5mV to 2V, negative-going. 5V to 100V, positive-going.

Amplifier. Gain switched in steps from 25 to 1000. Bandwidth 1 Mc/s. Rise time 0.3 μ.secs.

Pulse Height Analyser. Threshold variable between 5 and 50 volts, and between 5 and 100 volts. Gate width variable between 0-10 volts or 0-50 volts, or between 0-10%, 0-20% or 0-100%.

Ratemeter Ranges: From 3 cps. to 100,000 cps. in multiples of 3 and 10.

Resolution: 3 μ.secs.

Mean Probable Error Control. Automatically adjusted integrating time constants are arranged to provide a range of mean probable errors in five steps from 1% to 10%.

Recorder. Any standard recorder may be driven.

Stability. Ratemeter accuracy 1% changed by less than 0.5% for 10% mains change. Temperature coefficient: less than 0.05% /°C.

HV Supply. 250V to 2,000V in two ranges. Current available is 0.5mA up to 1,500V decreasing to 0.1mA at 2,000V. Stability better than 0.25% for ± 10% mains change. Ripple and noise less than 5mV above 200 c/s.

External Supplies. 300 volts at 20mA, 105 volts at 10mA, 6.3 volts at 2A.

Mains Input. 110-120V and 200-250V., 50/60 c/s. Consumption 200 watts.

Panel Size. 19" x 10½" x 14" deep (48 x 27 x 36 cm).

Weight. 70 lb. (31.7kg).

EKCO ELECTRONICS LIMITED

SOUTHEND-ON-SEA · ESSEX

EE 15 008 *for further details*

maximum performance . . .

. . . minimum space

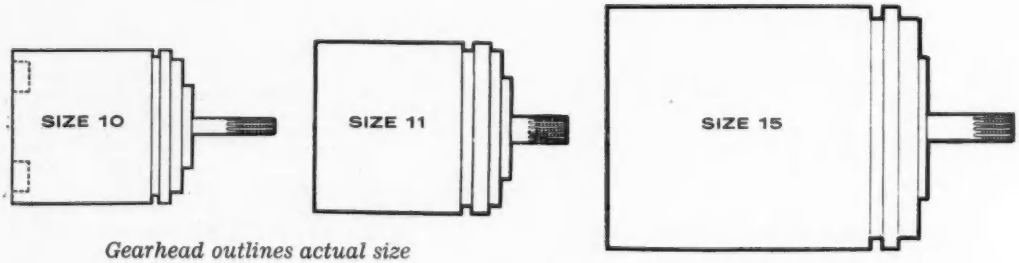
Size 11 Gearhead Coupled to Size 11 A.C. Servo Motor

Vactric high precision reduction gearheads are excellent examples of modern engineering in miniature. Manufactured from highest grade materials and machined to very close limits to reduce friction and wear to a minimum. Fitted with stainless steel bearings throughout the gearheads have very low inertia and backlash and high running torques relative to size of unit.

with Ball Bearing *'In-Line'* Gearheads

Available in a range of standard ratios, Vactric gearheads can be coupled directly to International Frame size D.C. or A.C. driving motors (sizes shown in table below) providing a compact 'in-line' assembly. By using two units in cascade reductions up to 1,000,000 : 1 can be obtained.

GEARHEAD	SIZE 10	SIZE 11	SIZE 15
Standard Ratios	10, 20, 40, 80, 100, 150, 300, 600 & 1000 : 1	10, 20, 24, 40, 80, 100, 150, 300, 600 & 1000 : 1	10, 20, 40, 80, 150, 300 & 600 : 1
Driving Motor Size.	07, 08 & 10	07, 08, 10 & 11	07, 08, 10 & 11



Gearhead outlines actual size

All sizes can be supplied as Speed Reducers where gear reductions are required other than directly from a motor drive. In this form, an additional input shaft on precision ball bearings is supplied mounted in an adaptor housing.

Vactric (Control Equipment) Limited

Vactric House, Sloane Street, London, S.W.1 Telephone · Sloane 9656

NRP 2385

EE 15 009 *for further details*

CALIBRATION OF ACCELEROMETERS

in the frequency range from 30 c/s to 20 kc/s by means of the

CALIBRATION EXCITER TYPE 4290.

The Calibration Exciter consists of a permanent magnet system and a vibration unit with driving coil and control acceleration pick-up.

Force Level:

0,2 kg force for frequencies up to 800 c/s.

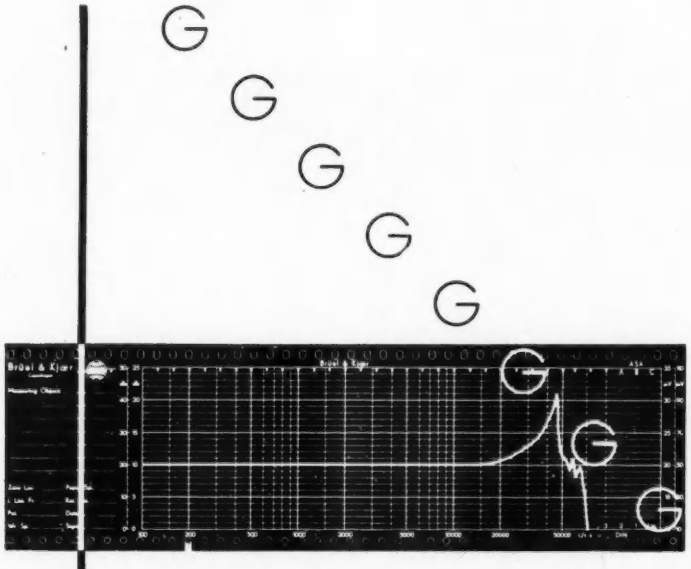
0,02 kg force for frequencies up to 20000 c/s.

Weight of vibration unit:

200 grammes.

Impedance of driving coil:

60 Ω.



Above is shown a frequency response curve for a Brüel & Kjær Accelerometer measured by means of the CALIBRATION EXCITER Type 4290. The curve is recorded automatically by using the built-in control pick-up to control the output voltage of the oscillator feeding the driving coil. The response is correct to within ± 1 db from 30 c/s to 20 kc/s and to within + 1 ÷ 3 db to 30 kc/s.

For further information phone or write to

Brüel & Kjær

Adr.: NÆRUM, DENMARK · Teleph.: NÆRUM 800500 · Cable: BRUKJA, COPENHAGEN

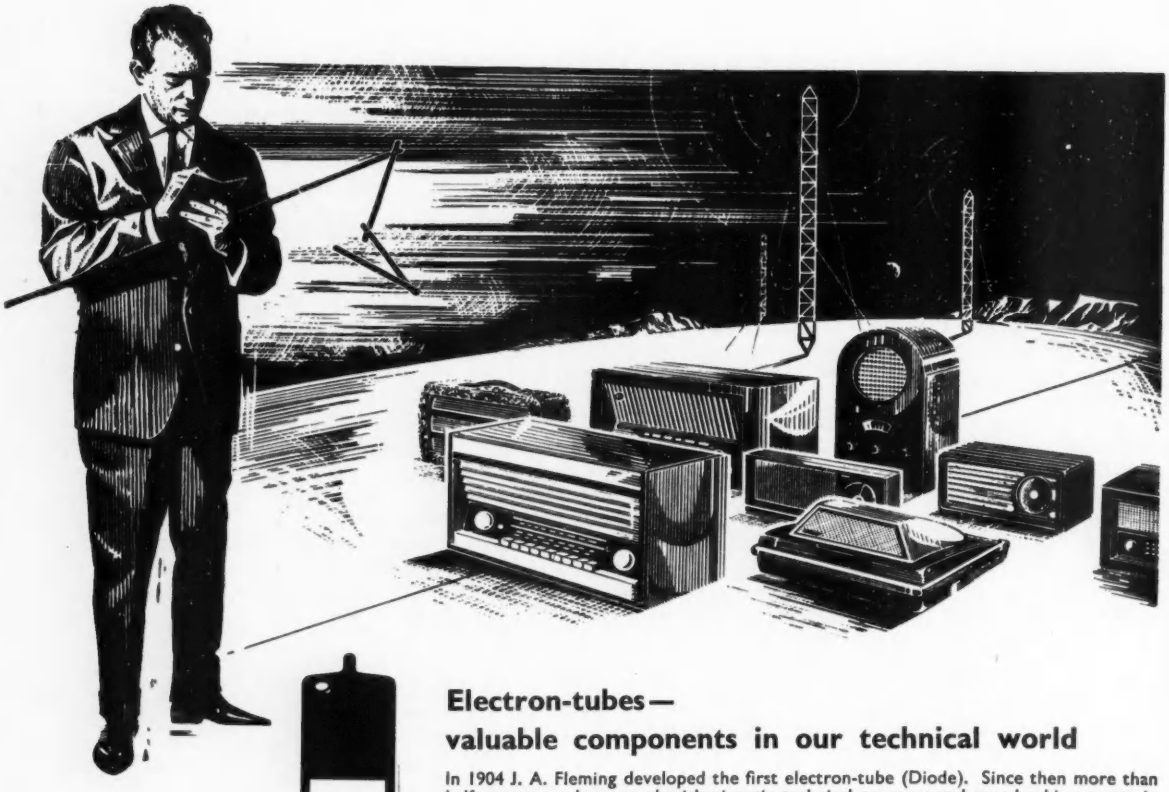
SALES AND SERVICE: B & K Laboratories, 4 TILNEY STREET, PARK LANE, W.1

EE 15 010 *for further details*

. . . there are 7.7 radio-receivers

to every meter of the equator —

In 1957 there were approximately 309 million radio-receivers all over the world*. If they would stand along the equator there would be about 7.700 receivers to a kilometer. This seems tremendous to us. Nevertheless, there is every possibility to ensure a further increase. Above all, the number of double-receivers, portable radio-receivers, car radio-receivers increases quickly . . . In the Netherlands 3 million radio-receivers for 2.8 million homes have already been registered. Has the upper limit been reached thereby?



EFFICIENT—
PROGRESSIVE—
RELIABLE—

Electron-tubes—
valuable components in our technical world

In 1904 J. A. Fleming developed the first electron-tube (Diode). Since then more than half a century has passed with gigantic technical progress and grand achievements in the electric industry . . . Year by year there has been an increasing demand for the different electron-tubes for radio-receivers. Trade with these important components became an interesting trading-branch on the world market.
The valve-works in the German Democratic Republic supply you with high-quality receiving-valves, miniature valves, long lasting valves among other items.
Efficient—progressive—reliable

* This number was estimated according to the statistical annual of the United Nations, New York, 1958.

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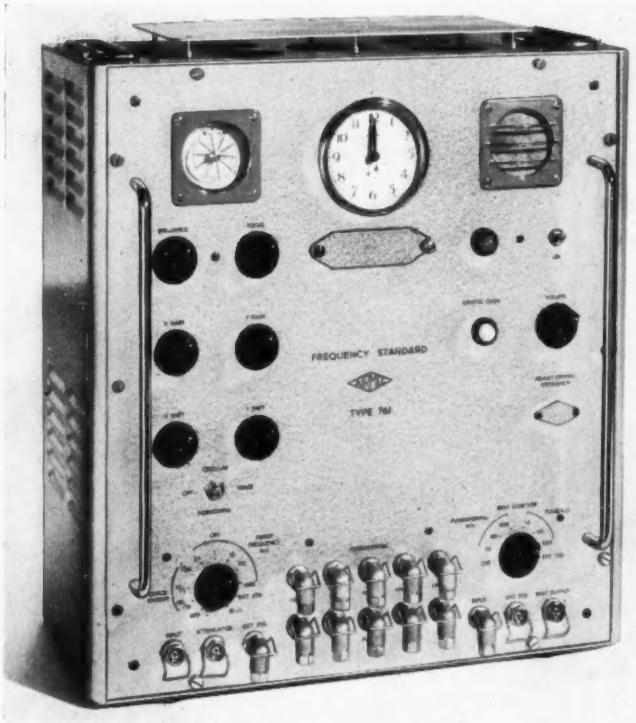
Representatives for England:
The Winter Trading Co. Ltd., 6 Harrow Road, London, W.2

Please forward your 294 page catalogue "receiving-valves" in English · French · German free of charge *

* Please cross out which does not apply

Name .....
Firm .....
Address .....
Country ..... Remarks .....

RFT Röhrenwerke



AIRMEC

FREQUENCY STANDARD

TYPE 761

FUNCTION

Provides an excellent crystal controlled frequency and time standard of small size and moderate cost. The short term frequency stability of better than 1 part in 10^6 obtainable upon installation improves with time and correct treatment up to a working stability approaching 1 part in 10^7.

OPERATION

Sinusoidal and pulse signals are produced at five standard frequencies, the pulse waveform being rich in harmonics. The instrument includes both an Oscilloscope and Heterodyning Circuit as independent facilities and is therefore extremely flexible in operation.

FEATURES

- **100 kc/s crystal housed in an oven controlled at 70°C.**
- **Standard signals provided at 100 c/s, 1kc/s, 10 kc/s, 100 kc/s, and 1 Mc/s.**
- **Identification of an unknown signal by Lissajous figure or beam modulated circular trace.**
- **Beat output available from a plug on the front panel.**
- **Suitable for rack mounting.**

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in instrumentation...

Airmec

makes most things... better

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Telephone : High Wycombe 2060

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by using Saunders-Roe Foil Strain Gauges. For example one application recently carried out by our Foil Strain Gauge Consultancy Service was monitoring of strains in cylinder liners of ship's diesel engines undergoing sea trials.

The judicious use of Foil Strain Gauge techniques can lead to more efficient designs with consequent economies in production and cost over a wide range of industrial activity. Saunders-Roe engineers are actively engaged on this work and can help you with your problems whatever your interests.

Transducers for industrial instrumentation can be supplied with Foil Strain Gauges incorporated to measure, for example, weight, pressure, torque, tractive effort and horsepower.

For details of Saunders-Roe Foil Strain Gauges and Consultancy Service, write to . . .

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STRAIN GAUGE DIVISION,

OSBORNE, EAST COWES, ISLE OF WIGHT

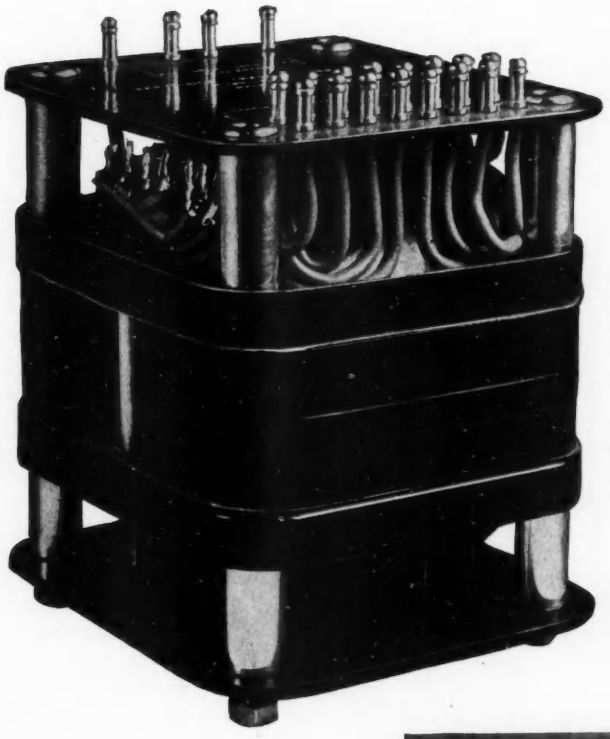
cpn/sas/19

MS

Silicone Electrical Insulating Materials

Silicone Rubbers and Resins for Flexible Sleevings

Silastomer silicone rubber sleeving used on terminal leads in a Partridge transformer – courtesy of Partridge Transformer Co. Ltd.



SILASTOMER* AND SILASTOMER/GLASS SLEEVING

Silastomer can be extruded and cured to form thin-walled sleeving that is elastic, extremely flexible and has good dielectric properties. It is recommended for operation over the temperature range –75°C to +250°C.

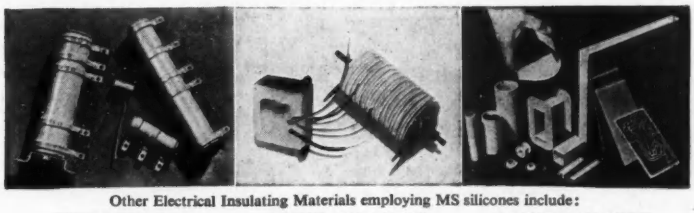
Braided glass sleeving is also available coated with Silastomer silicone rubber. It is based on glass yarn and is supplied in various colours and in continuous lengths. This flexible sleeving retains its good dielectric properties and tear resistance from –55°C to +250°C.

**Silastomer is a registered trade mark of Midland Silicones Ltd.*

SILICONE-VARNISHED GLASS SLEEVING

Flexible sleeving, available in various colours, is made from braided continuous-filament glass fibres saturated or varnished with a silicone resin. Heavily varnished sleeving with an average breakdown of about 4 kV is used where maximum electric strength is required. Silicone saturated sleeving is used as low voltage insulation and as a covering which will subsequently be varnish-impregnated.

Write for Silicone Notes C19 listing the suppliers of silicone flexible sleevings and other silicone insulating materials.



Other Electrical Insulating Materials employing MS silicones include:

SILICONE RESINS FOR RESISTOR COATINGS

SILICONE COLD-CURING RUBBER

SILICONE RESIN BONDED GLASSCLOTH LAMINATES

MIDLAND SILICONES LTD — **first** *in British Silicones*

Associated with Albright & Wilson Ltd., and Dow Corning Corporation

58 KNIGHTSBRIDGE · LONDON SW1 · KNIGHTSBRIDGE 7801 · **Area Sales Offices:** *Birmingham · Glasgow · Leeds · London · Manchester* · **Agents in many countries**

TSW/MS120

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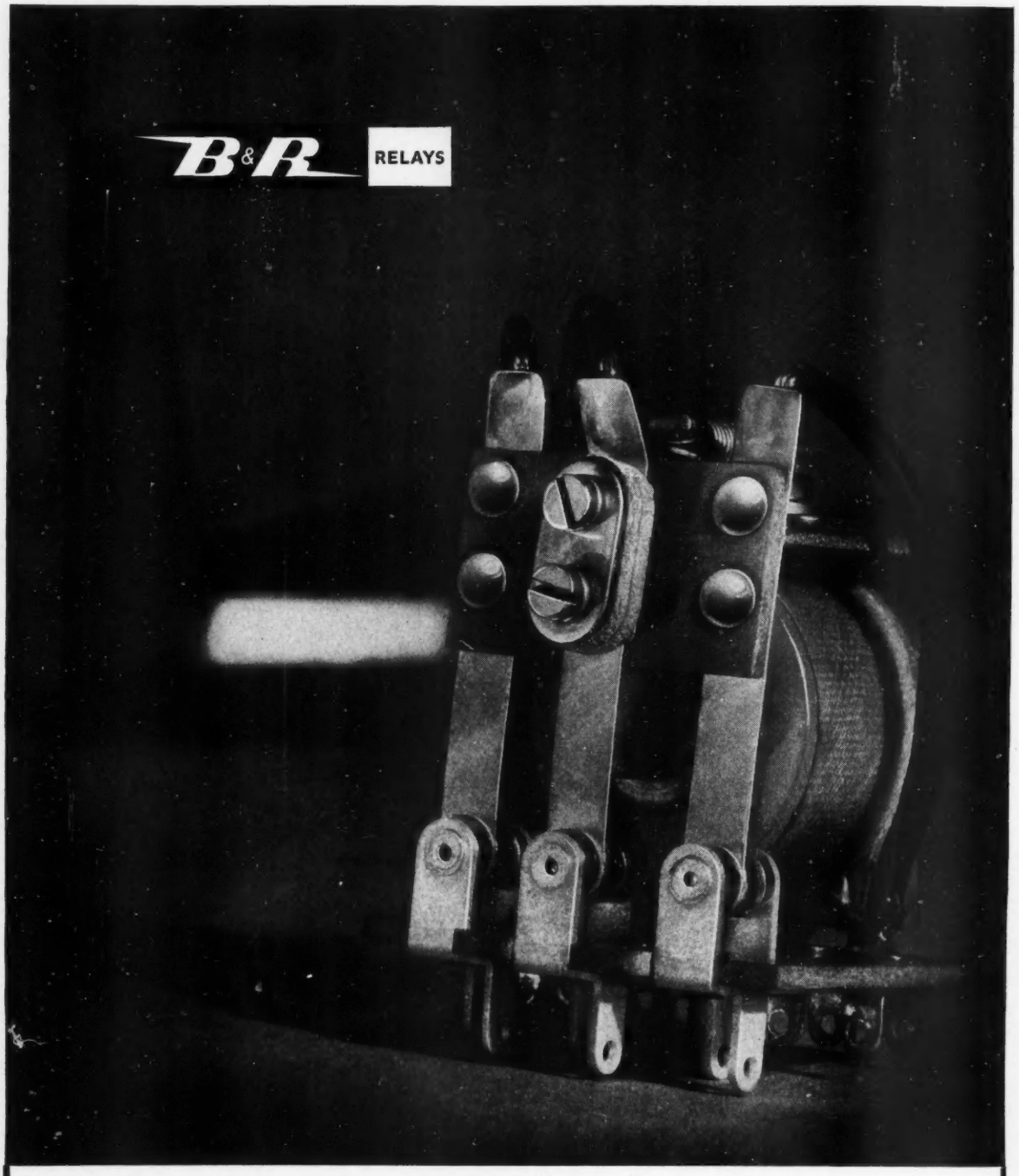
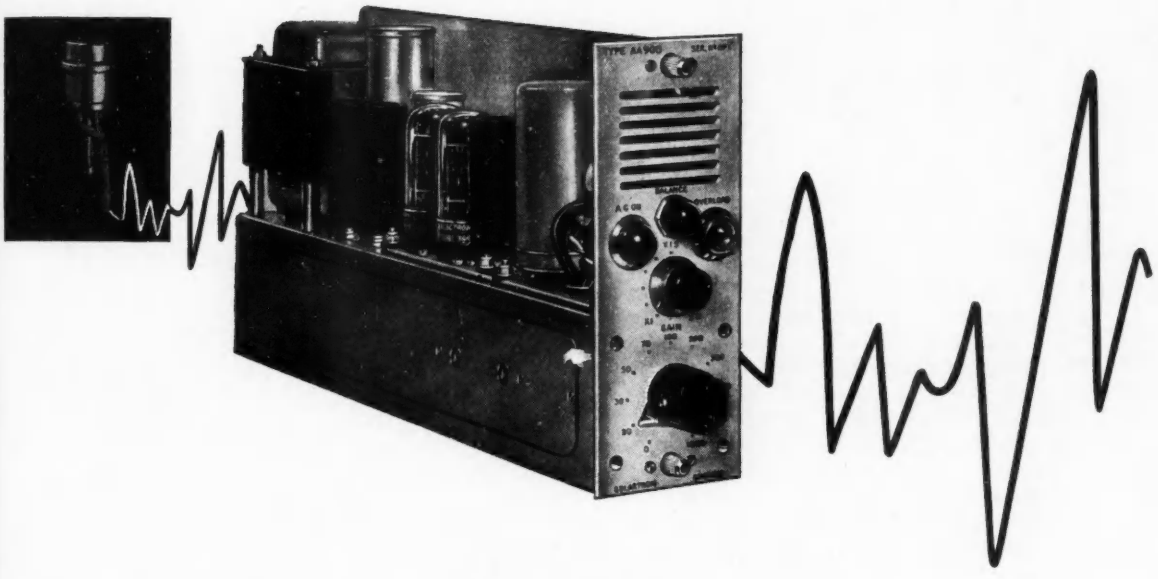


In addition to the well established range of B. & R. relays,
the first of a new series is the type D.52—AC operated relay and its DC counterpart the D.02. These relays are inexpensive and small in size, outside dimensions being 1⅜″ x 1⅜″ x 1⅞″.
The 3 change-over contacts are rated at 10A at 30V. DC, and 5A at 240V. 50 c/s, AC. The unit can be supplied tropicalised to meet generally, Ministry of Defence Specification D.E.F. 5000. Write to Dept. G2, for full details.

B. & R. Relays Ltd · Temple Fields · Harlow · Essex
Member of the Gas Purification Group



accurate amplification for all low-level transduced signals

Designed for the distortion-free amplification of low-level signals from strain gauge, pressure sensitive and other types of transducers, the Solartron AA 900 is a wideband DC amplifier of exceptionally high performance.

Throughout the range DC to 40 Kc/s, inherently low drift and noise figures are achieved by chopper corrections and use of advanced negative feedback techniques. A large degree of loop feedback ensures that precisely controlled gain conditions are maintained with high stability.

Ground loop problems are reduced as the common voltage rail is not earthed to chassis, and the input is held above nominal earth.

Each amplifier is provided with its own integral power supply and may be operated from nominal 115 or 230 volt, 50/60 c/s sources.

specification:

GAIN (Phase-Inverting)
Steps of 20, 30, 50, 70, 100, 200, 300, 500, 700 and 1000 with continuous 1 to 2 times variation of each step by potentiometer control.

GAIN ACCURACY
± 1% DC to 2 Kc/s.
± 3% DC to 10 Kc/s.

INPUT IMPEDANCE
100 K ohm.

OUTPUT IMPEDANCE
Less than 1 ohm in series with 25 microhenries.

EQUIVALENT INPUT DRIFT (After Warm-up)
Less than ± 2 microvolts for 40 hours when used with regulated mains supply. A ± 10% change in mains supply causes ± 5 μV change.

LINEARITY
Better than 0.1% to 2 Kc/s.

FREQUENCY RESPONSE
Less than 3 db down at 40 Kc/s.

DC OUTPUT CAPABILITY
± 35 volts into loads greater than 1 K ohm.
± 35 mA peak current.

SOLARTRON

WRITE FOR FULL DETAILS TO:

The Solartron Electronic Group Ltd.
Thames Ditton, Surrey
Telephone: EMBerbrook 5522

EE 15 016 *for further details*

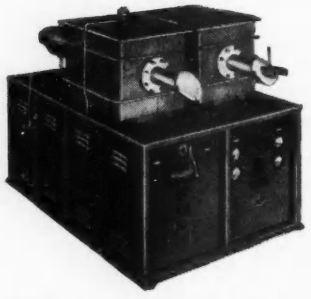
Furnaces

specially designed for the

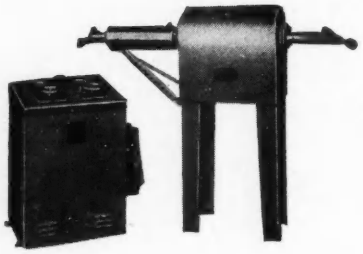
electronic industry

For the special purpose furnaces required in electronic work the majority of leading manufacturers in the industry have turned to Royce. Being specialists in furnaces for individual requirements, Royce have wide experience in adapting proved basic designs to the particular processes of different manufacturers. However unusual the application, Royce will be pleased to submit a drawing and specification, and will readily co-operate with customers, in strict confidence.

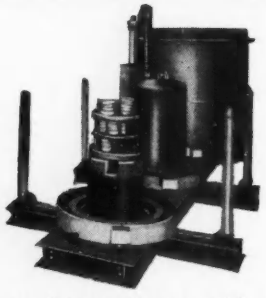
Royce equipment ranges from low temperature ovens to furnaces operating at temperatures up to 2,000 C. May we discuss your heat treatment problems with you?



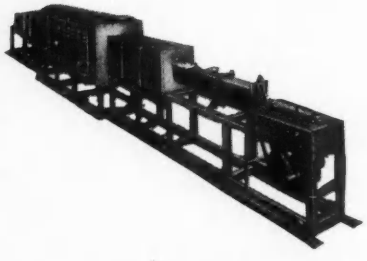
High temperature hydrogen tube furnaces



Platinum and platinum/rhodium tube furnaces with impervious inner tubes



Bell type furnaces for use with controlled atmospheres or vacuum



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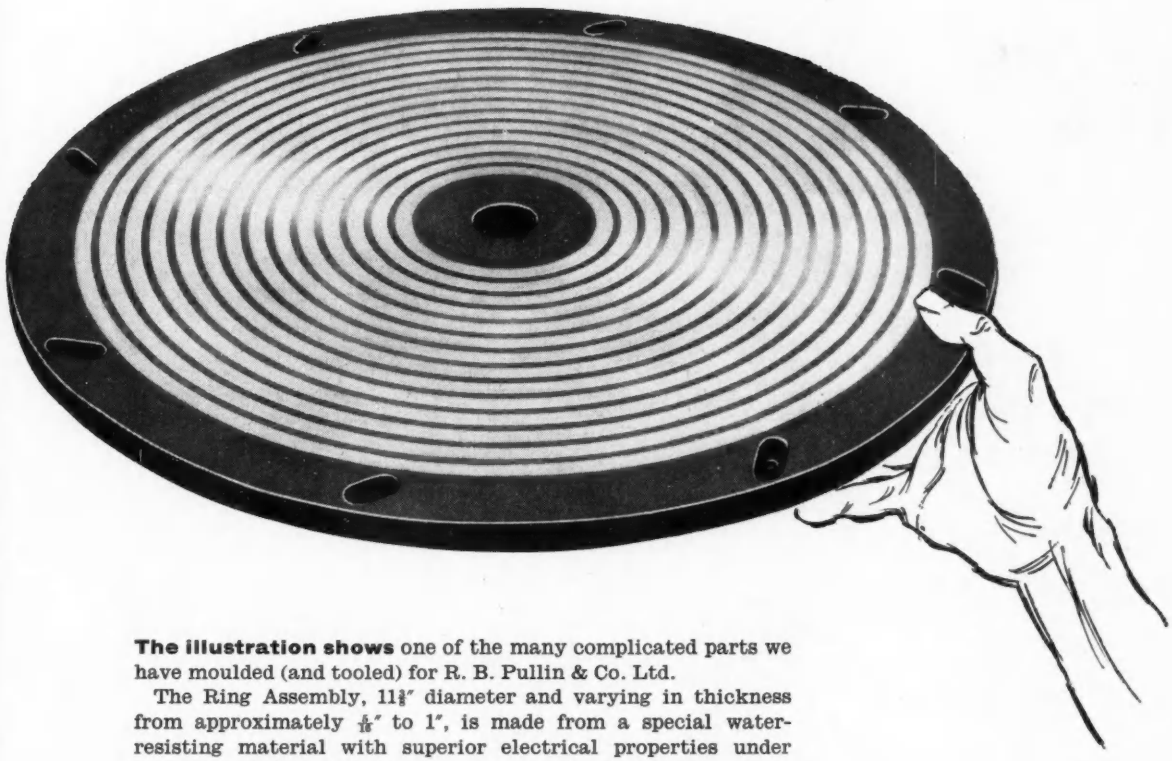

The illustration shows one of the many complicated parts we have moulded (and tooled) for R. B. Pullin & Co. Ltd.

The Ring Assembly, 11⅜" diameter and varying in thickness from approximately $\frac{1}{16}$" to 1", is made from a special water-resisting material with superior electrical properties under humid conditions. The fourteen concentric silver rings, shown moulded in position, are so costly that rejects had to be avoided and, indeed, they were.

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D.C. Anode Voltage	*20 kV*
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Screen Voltage	*1.25 kV*
Grid Voltage	*600 V*
Pulse Anode Current	*16 A*
Peak Anode Current	*18 A*
Pulse Output Power	*300 kW*
Duty Cycle	*0.001*
Pulse Length	*2 μsecs*

A lower rated version, the C1111, *is also available.*

Abridged Data

Type	Plug-in replacement for	Overall Length Max.	Overall Diameter Max.	Net Weight	Heater Voltage	Anode Voltage Max. D.C.	Peak Anode Voltage Max.	Peak Anode Current Max.	Screen Voltage Max.	Anode Dissipation Max.
C1133 (CV2416)	4PR60A 715C CV427 CV2752	152 mm	65 mm	9 oz.	26	20 kV	25 kV	18 A	1500 V	60 W
C1111	715C CV427 CV398	152 mm	65 mm	9 oz.	26	17.5 kV	20 kV	15 A	1500 V	60 W

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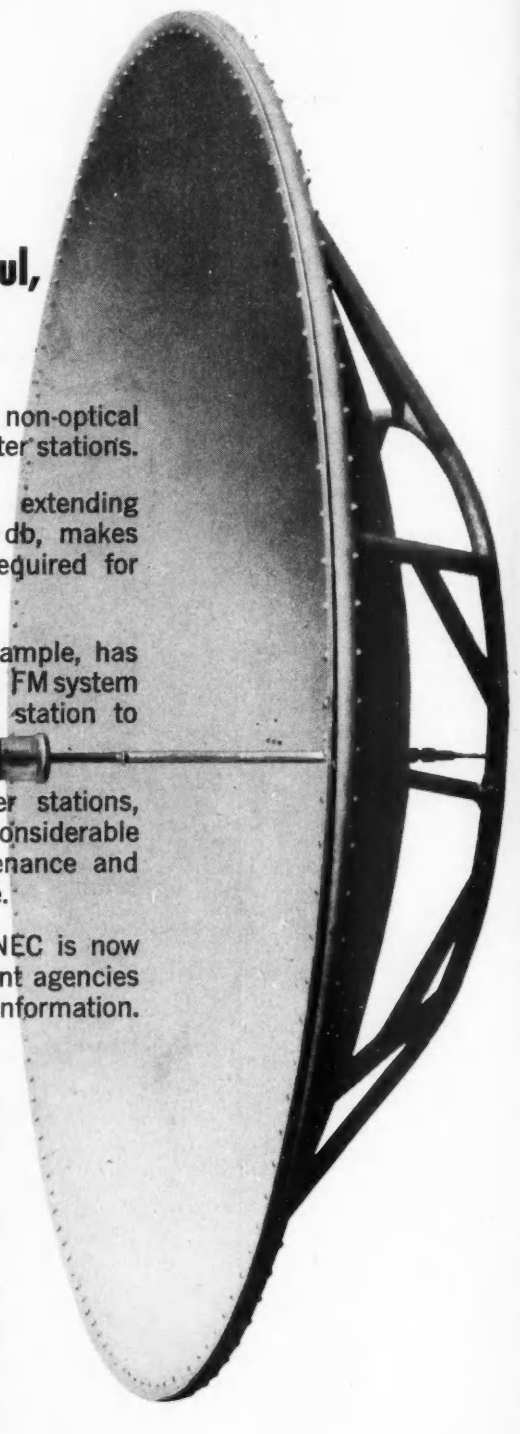

Microwave 60-channel voice transmission over a non-optical path up to 300 MILES is now possible without repeater stations.

NEC's High Sensitivity Reception System, by extending threshold level and improving S/N ratio 10 to 13 db, makes this hop with only 1/20 of the power output required for conventional systems.

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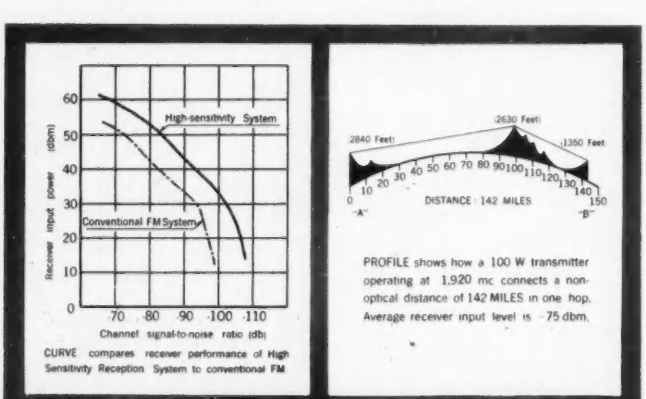
By eliminating high-power amplifiers and repeater stations, the High Sensitivity Reception System results in considerable reduction in initial investment. Savings in maintenance and power consumption are estimated at 40% or more.

Extensive propagation tests have been made, and NEC is now prepared to supply commercial users and government agencies anywhere in the world. Please write for detailed information.

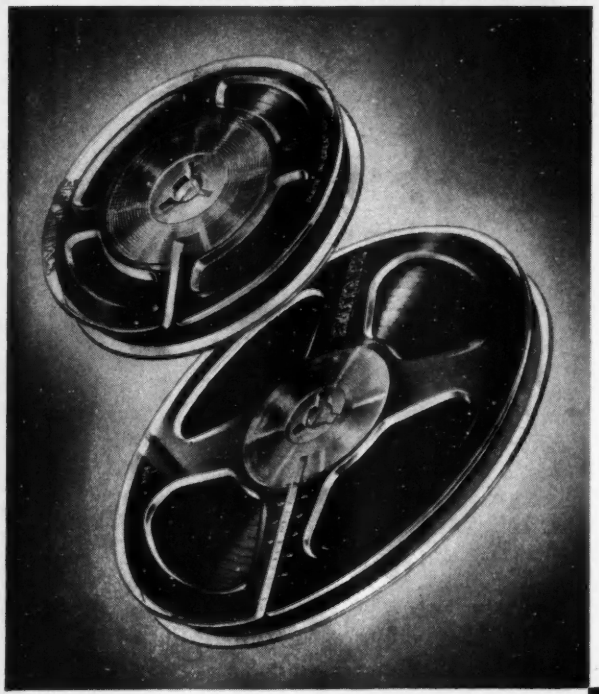


CURVE compares receiver performance of High Sensitivity Reception System to conventional FM

PROFILE shows how a 100 W transmitter operating at 1,920 mc connects a non-optical distance of 142 MILES in one hop. Average receiver input level is −75 dbm.

NEC **Nippon Electric Company Ltd.**
Tokyo, Japan
Electronics / Communications Systems

Emitape



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99/3		3" dia.	250′	—	9 6
88/3N		3¼" dia.	175′	—	7 6
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88/6	"Junior"	5" dia.	600′	£1 3 6	£1 1 0
99/9		5" dia.	850′	£1 10 6	£1 8 0
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99/12		5¾" dia.	1200′	£1 17 6	£1 15 0
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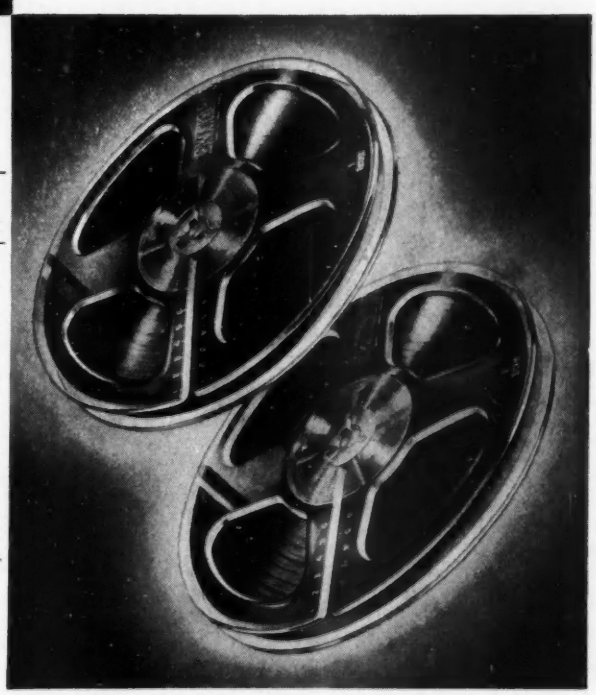
99/18		7" dia.	1800′	£2 12 6	£2 10 0
88/18	"Professional"	8½" dia.	1750′	—	£2 17 6
99/24		8½" dia.	2400′	—	£3 12 6



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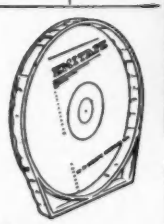

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Indium-arsenic
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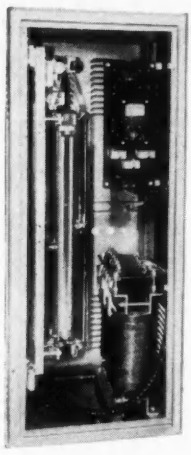
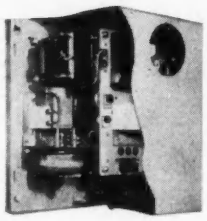
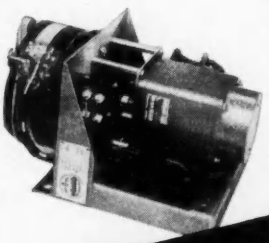
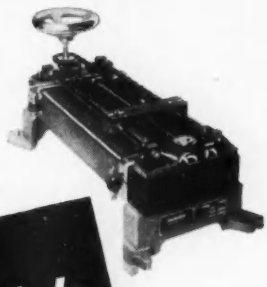
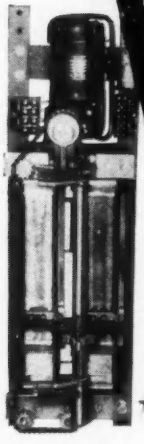
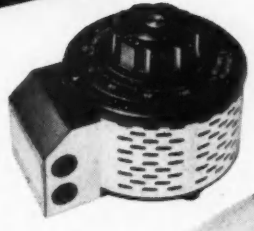
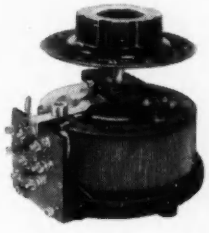
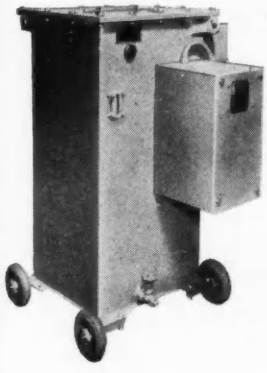





28 Standard Models from 250VA-110kVA

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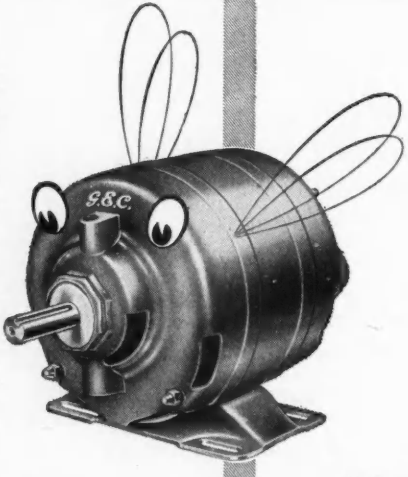

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type S0530

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dimensions	W: 24″ H: 23″ D: 15″

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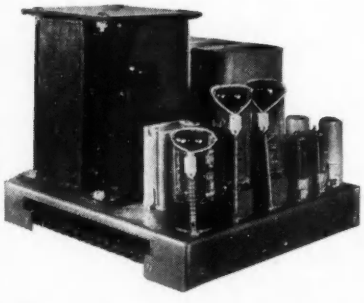

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polarity	reversible
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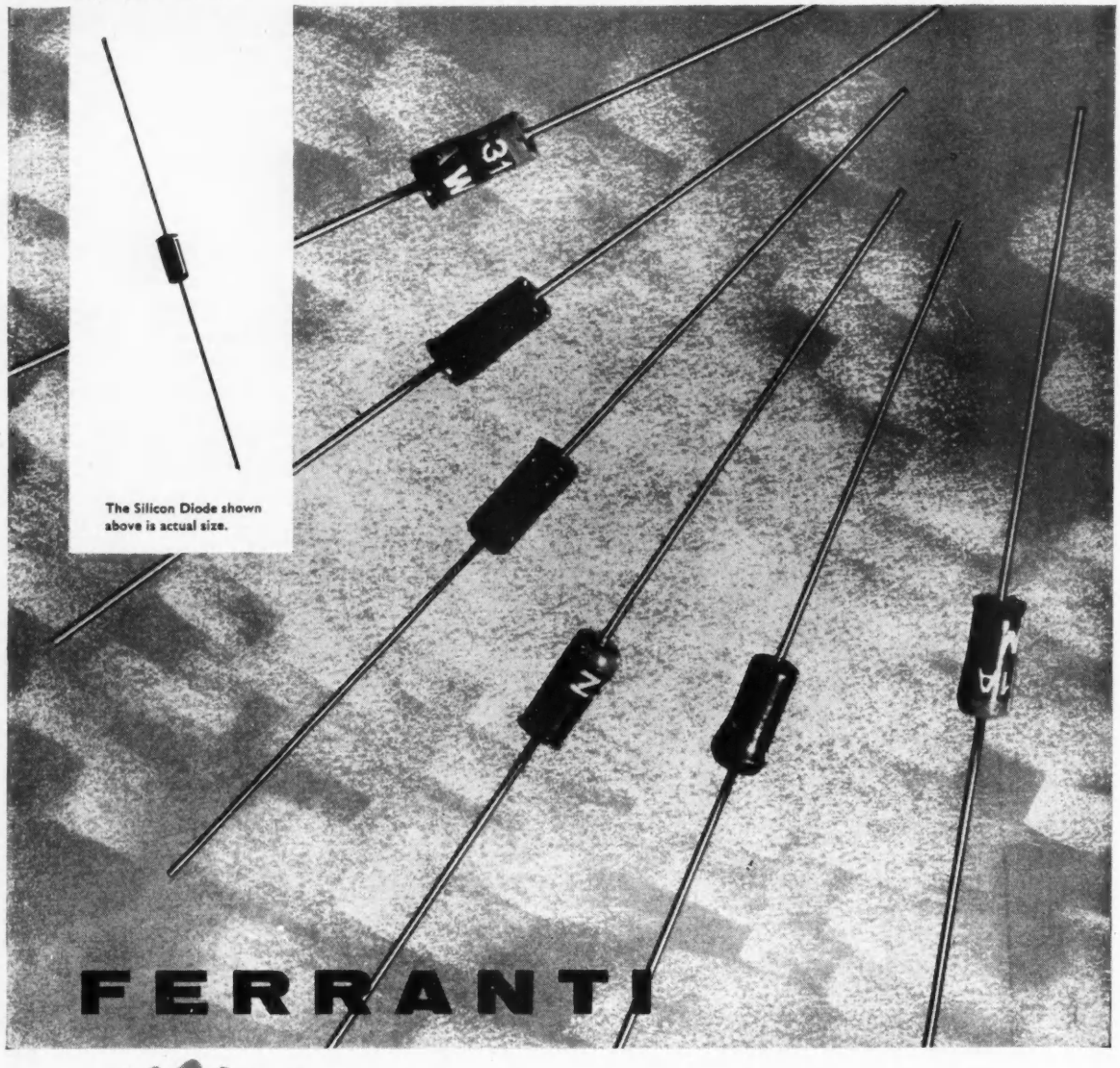

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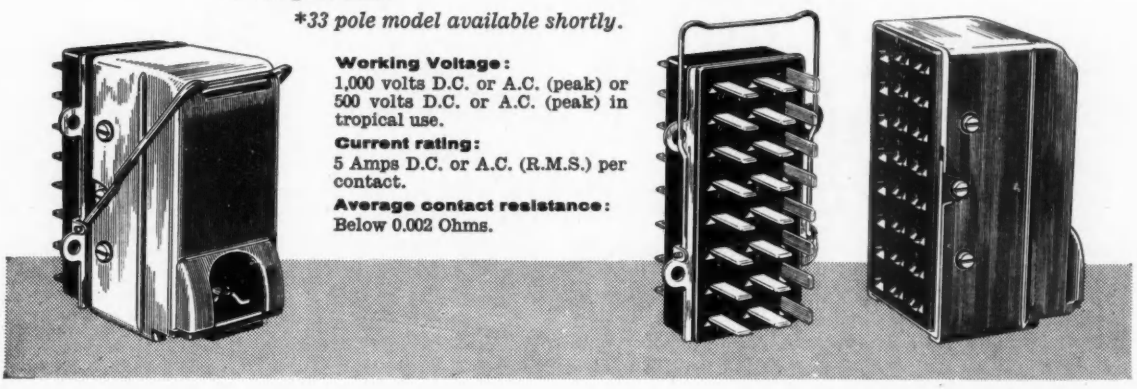
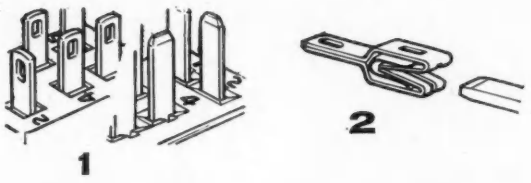
**33 pole model available shortly.*



Working Voltage:
1,000 volts D.C. or A.C. (peak) or 500 volts D.C. or A.C. (peak) in tropical use.

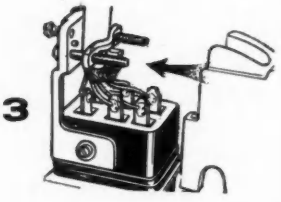
Current rating:
5 Amps D.C. or A.C. (R.M.S.) per contact.

Average contact resistance:
Below 0.002 Ohms.



1

2



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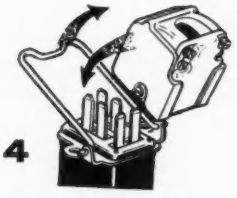

4

British Patent 700999

1 Terminal numbers are moulded into plug and socket bodies, both next to soldering tags and on mating face. This facilitates wiring and cableform testing without removing covers.

2 Socket clips have split limbs so that 4 areas are in contact with each plug blade. Contact resistance is low and constant, providing a high standard of contact reliability and a minimum life of 10,000 operations.

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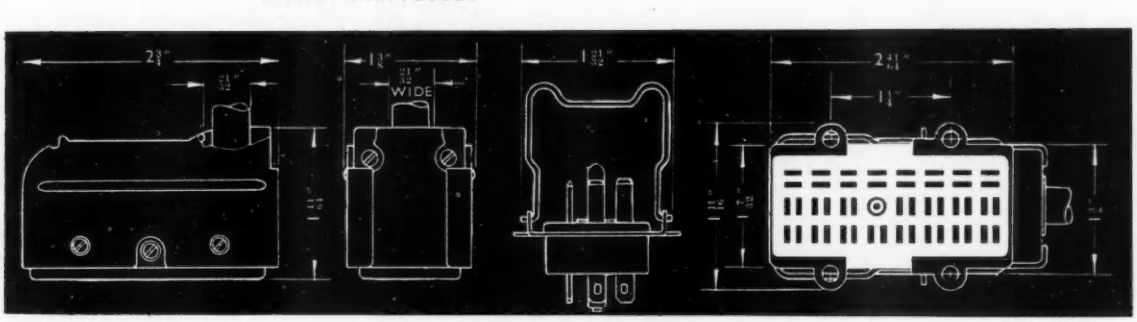
4 A wire retaining loop clips over the radiused corner of the cover and engages positively with a cast groove.



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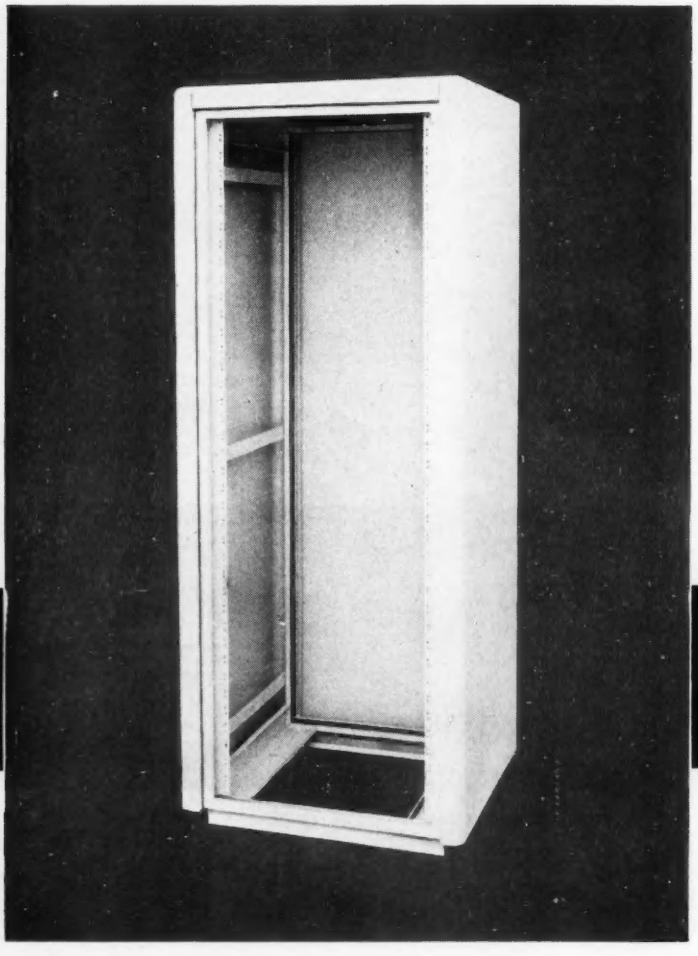
Standard Racks
from
LUNDS
of Wandsworth



Lunds of Wandsworth present a new range of top quality Standard Racks. Designed to meet all needs, the new Lunrac is easily adaptable to suit varying conditions and specifications.

Lunrac features:

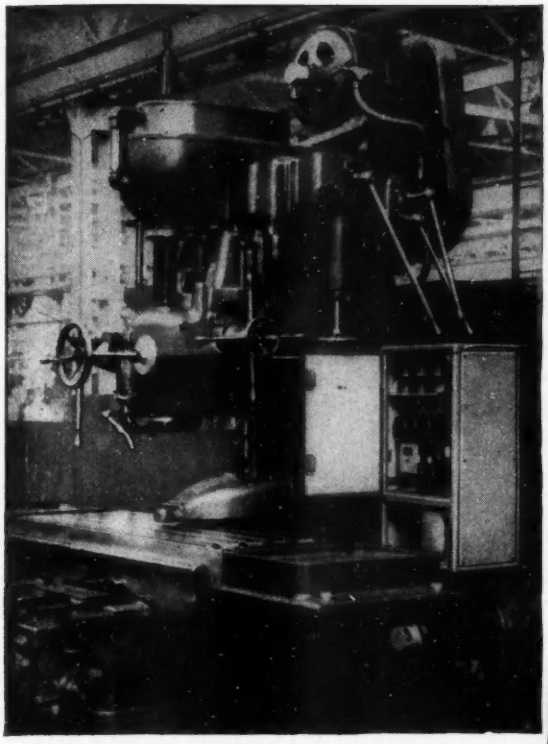
* **Rigidly constructed from 10 gauge formed steel sections and finished in silver grey hammered stoving enamel.**
* **Depth of 19″ for standard panel mounting.**
* **Easy accessibility through hinged rear door and quick release side panels.**
* **Facilities for floor mounting or on castors.**
* **Price £38.10.0.**
* **Single or multi bay assemblies.**
* **Racks can be dust proofed, force ventilated or sound deadened.**

Further details on application to:

LUNDS

OF WANDSWORTH
Bendon Valley,
London, S.W.18

Telephone: VANdyke 7676



AEI

Quality Speed Controls

(Left) Herbert 28A vertical milling machine with electronically controlled motor driving the feed. Speed range of 60/1200/3000 rpm.

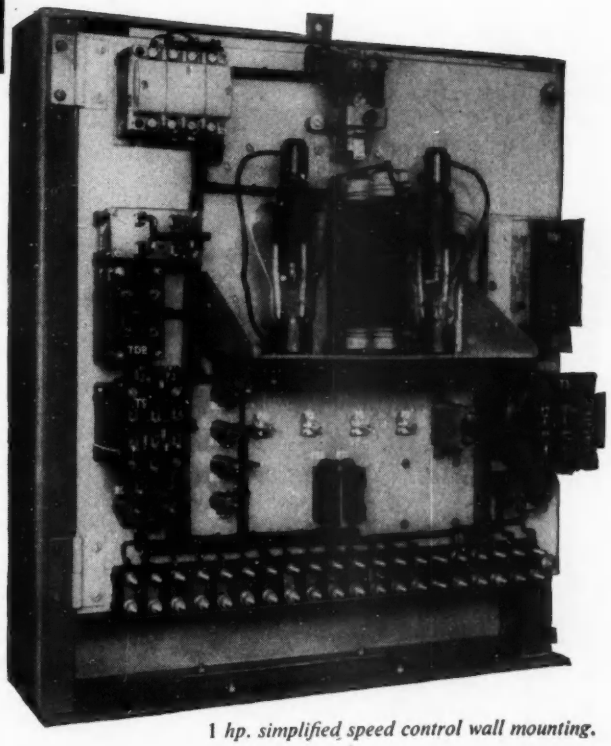
The reliability of A.E.I. electronic motor speed controls has been proved by years of practical service in all branches of industry. The types of speed control available are :—

SIMPLIFIED THYRATRON SPEED CONTROLS
Using a magnetic amplifier and two thyratrons, these equipments offer fingertip stepless speed control of a D.C. motor from zero to top speed. Speed holding accuracy of 2% despite load changes and automatic acceleration to any set speed. This control has a constant torque characteristic, but constant horsepower over a 3/1 range can be obtained.

HIGH ACCURACY THYRATRON SPEED CONTROLS
Using an amplifier with two thermionic valves, two thyratrons and a tachogenerator, these high accuracy controls embody all the features of the simplified equipments with the additional advantage of holding the speed to an accuracy of $\pm \frac{1}{4}\%$ of top speed despite load and supply variations.

MAGNETIC AMPLIFIER CONTROLS
Speed control of motors below 1 hp. Accuracy of speed holding to within 2% of top speed.

For further details write for publications Nos. 98/1-1 7098/3.



1 hp. simplified speed control wall mounting.

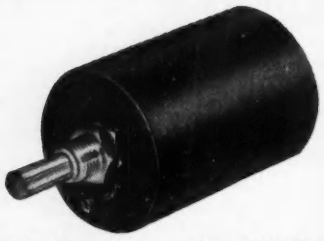
ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

MOTOR & CONTROL GEAR DIVISION — RUGBY & MANCHESTER, ENGLAND

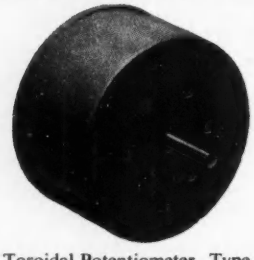
INCORPORATING THE MOTOR & CONTROL GEAR INTERESTS OF BTH & M-V

Precision Potentiometers..

by P·X·F

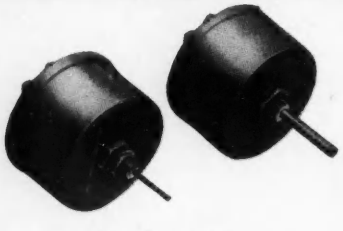


Helical Potentiometer. Type PX/4/H.10 Turnings 3 and 10.



Toroidal Potentiometer. Type B and E with ball races.

Ceramic Potentiometer, eight sizes 10—1,000 watts.



Low Torque Sub-miniature, Type F and G.

Using only the finest ceramic as insulation, and with complete rings for maximum strength, P. X. Fox potentiometers are approved by all Government Departments and are especially recommended for tropical service.

For full details and specifications of the large range of toroidal and helical potentiometers, please write to:

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Tel: Horsforth 2831/2. Grams: Toroidal LEEDS.

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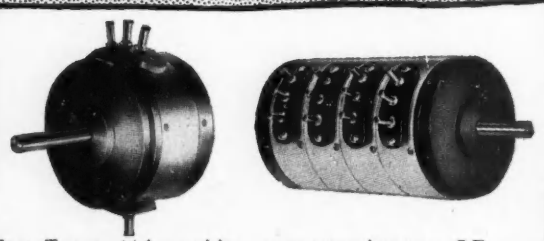
Tel: Orpington 21031



Low Torque, high precision, servo mounting types S.F., S.G., S.B.

EE 15 033 *for further details*

U.H.F. MEASURING EQUIPMENT

With basic measuring instruments, such as the Slotted Line or Admittance Meter, generators, detectors, and a wide range of inter-related coaxial elements, all linked through the ingenious Type 874 connector, 'GENERAL RADIO' offer the scientist and engineer a 50-ohm U.H.F. measuring system that is

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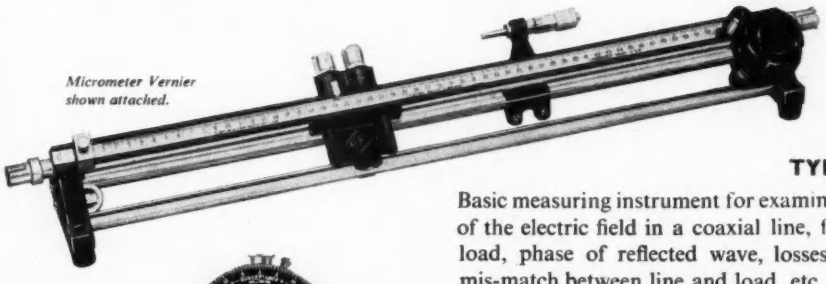
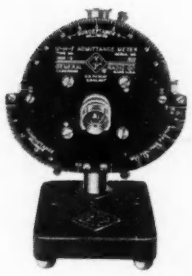


Micrometer Vernier shown attached.

TYPE 874-LBA SLOTTED LINE:
Basic measuring instrument for examination of the standing-wave-pattern of the electric field in a coaxial line, from which VSWR, impedance of load, phase of reflected wave, losses in attached elements, degree of mis-match between line and load, etc. can be determined. Accurate and straightforward in use. Frequency range 300-5000 Mc/s (with some loss in accuracy : 150-7000 Mc/s). Also available : Type 874-LV Micrometer Vernier (for measurement of high VSWR). Type 874-MD Motor Drive for oscillographic display of standing-wave pattern.



TYPE 1602-B ADMITTANCE METER:
A compact and versatile instrument, accurate and rapid in use, for determining the components of an unknown admittance in the VHF-UHF range. Scales read directly in conductance and susceptance, *independent of frequency*. With unknown connected through quarter-wavelength line, scales read in resistance and reactance. Can be used for measurement of VSWR and reflection coefficient, matching or comparison of impedances, and measurements on balanced line circuits (with the Type 874-UB 'Balun'). Frequency range 41-1500 Mc/s. (Down to 10 Mc/s, with correction). Includes conductance and susceptance standards.

THE GR SYSTEM

Keystone of the entire system is the unique Type 874 coaxial connector, fitted to all elements (see illustration below); this low-loss connector, any two of which, *although identical*, can be plugged together gives the system versatility and ease in setting-up for any measurement, and is characteristic of G-R's clear-sighted engineering philosophy. Low-loss adaptors are obtainable to link up with other systems.

Around this connector G-R have developed a wide range of coaxial elements :— lines, stubs, filters, attenuators, capacitors, inductors, insertion units, ells, tees, terminations, etc., of excellent electrical characteristics. These coaxial elements, together with generators, measuring gear, detectors, 'Balun' (balanced-to-unbalanced transformer) and other instruments form a complete and integrated line of high-frequency measuring equipment, designed for highest accuracy, dependability and convenience in use . . . in keeping with the G-R tradition of supplying only the finest in laboratory equipment.

Identical Type 874 connectors.

Claude Lyons Ltd.

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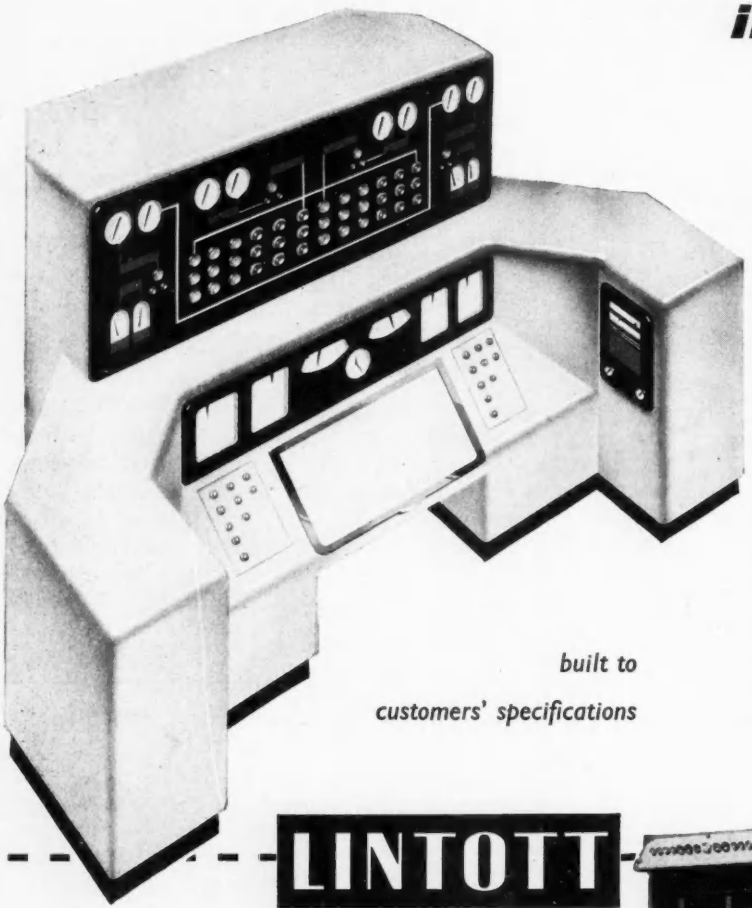
EE 15 034 *for further details*

* *the case for perfect housing in electronics*



built to customers' specifications

FOR CONTROL

Desks and Panels

Lintott fabrication serves the electronic and nucleonic industries with Control Desks and Panels that enhance the operating scheme. Working in close collaboration with designers, Lintott produce units for all forms of process control, burner control, nuclear control, etc. This includes sheet metal work, surface finishing, flow diagram mounting and installation of instruments and switchgear. Perfect housing helps to sell your equipment. Let Lintott quote for construction on your next project.

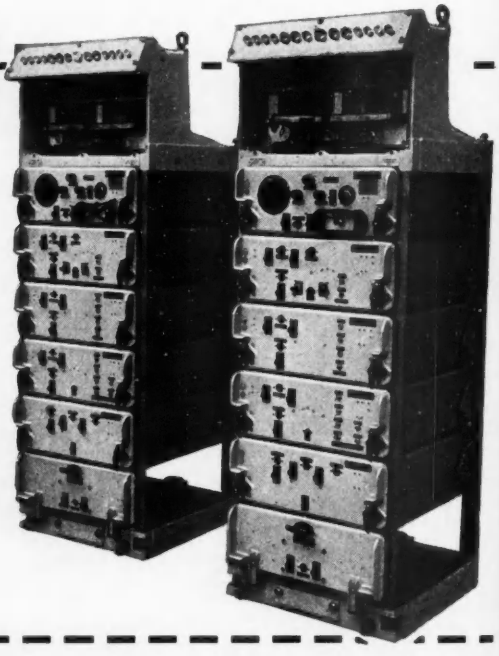
LINTOTT

FOR EQUIPMENT...

a flexible system of cabinets

Lin-cabinets provide a standard and yet completely flexible system for housing electronic and electro-mechanical equipment. They are designed to accommodate any arrangement of components and any combination of chassis. Each unit is self-contained, with built-in cooling or heating facilities, and are suitable for slight pressurisation. The three standard drawers of 8″, 12″ and 16″ can be used in any combination to give a total height of 52″ and any number of cabinets can be interlinked. Lin-cabinets are K114 approved for the three Services and lend themselves to many applications. Plan your equipment layout with Lin-cabinets in mind and enjoy low installation costs, low maintenance costs, with maximum efficiency.

Data Sheet LC. No. 1.



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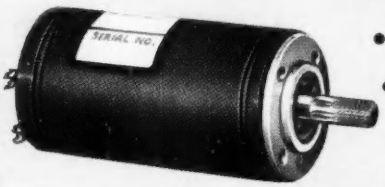
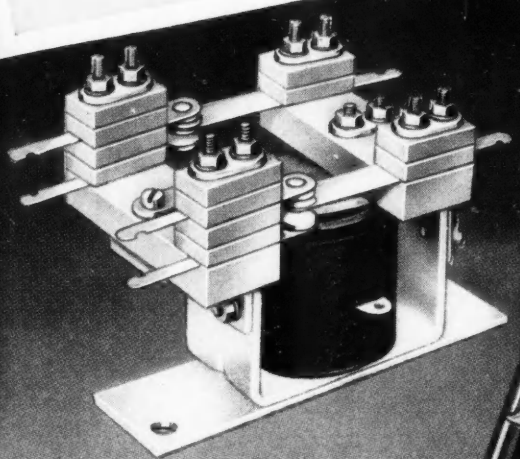
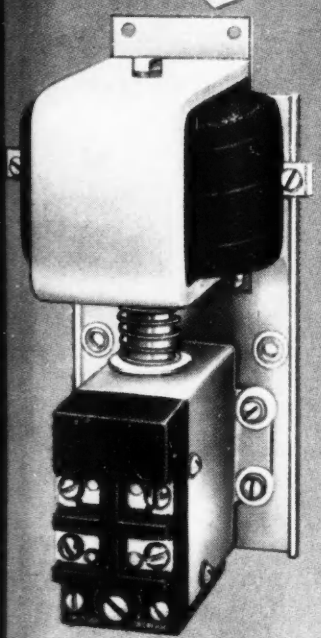


- Linear voltage/speed characteristic.
- Compact design for standard fixing.
- For d.c. servo systems.
- Output voltage: 4 per 1000 rpm.





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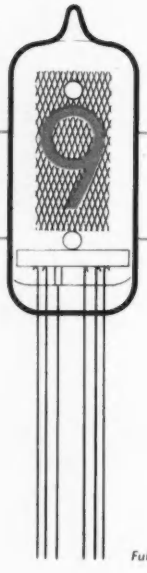
TYPE DISPLAY

NOW MINIATURISED

FOR INSTANTANEOUS

CLOSE-RANGE READOUT



Full Size

THE GR. 10. W

In many digital applications it is often wasteful of valuable equipment space to employ the larger types of numerical indicators. The equipment design may call for a much more personalized type of display such as that required for control consoles, desk equipments, and similar layouts.

It is with these applications in mind that we introduce a newcomer to the DIGITRON range.

Whilst retaining the basic construction of the standard GR.10.G numerical indicator tube, the GR.10.W, being wire ended, can be soldered directly into the circuit and enables the designer to make full use of the display area by mounting these miniatures immediately adjacent to each other. This represents a considerable improvement in the readout facility at close range.

Like previous DIGITRONS, the numerical design of the GR.10.W is "human engineered" to eliminate readout error and again numbers are visible over wide viewing angles.

The miniature side-viewing GR.10.W with its robust construction, vivid presentation and its "no base" facility represents a big step forward in miniature display techniques.

OTHER SIDE-VIEWING DIGITRONS INCLUDE:

DIGITRON GR.2.G

Designed to display "plus" or "minus", this tube will find many applications in digital equipments requiring unambiguous sign display.

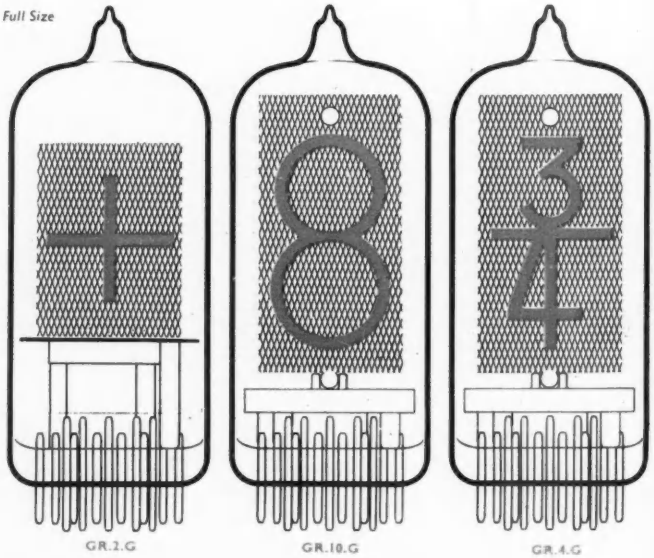
DIGITRON GR.10.G

The original DIGITRON—providing a clear numerical readout up to 50 feet over wide viewing angles. Ideal for audience readout.

DIGITRON GR.4.G

A recent introduction to the DIGITRON range, the GR.4.G displays ¼, ½, ¾, or 1 in vivid numbers styled for easy readout. Suitable for applications concerned with monetary display.

Full Size



GR.2.G GR.10.G GR.4.G

May we send you full information on the DIGITRON range of display tubes. Write to:—

TECHNICAL SERVICES DEPT.

ERICSSON

TUBE DIVISION

BEESTON, NOTTINGHAM

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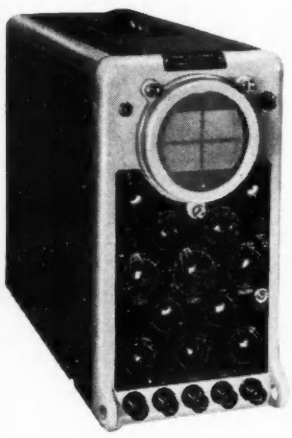
Four first-class performers

These four Cossor Oscillographs, each designed for an important range of applications, offer first-class performance backed by rigid adherence to published specifications.

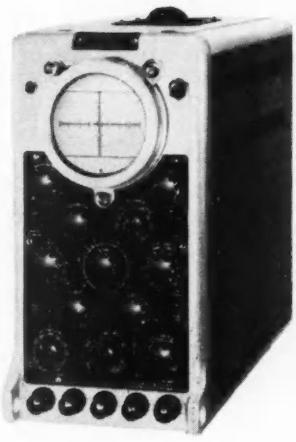


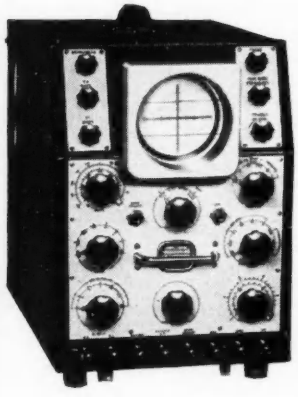
MODEL 1065 PULSE OSCILLOGRAPH

Tube: single-beam, P.D.A.
Bandwidth: d.c. to 15 Mc/s (—50%).
Sensitivity: 250 mV/cm.
Overshoot: less than 3%.
Time-base: triggered or repetitive over range 40 cm/sec to 5 cm μsec.
X Amplifier: gain 5, continuously variable.
Time-base delay: 2 ranges, continuously variable.
Calibration: voltage and time, by calibrated shifts.
Probe: 1.5 MΩ, 12 pF.

MODEL 1058 FOR THE TV & RADIO ENGINEER

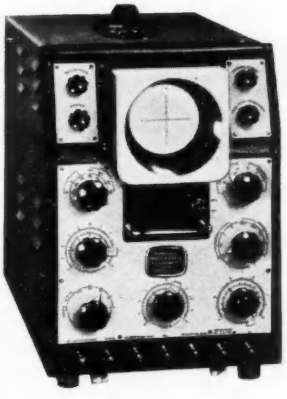
Tube: single-beam
Bandwidth: d.c. to 6 Mc/s (—50%).
Sensitivity: 250 mV/cm.
Time-Base: triggered or repetitive, over range 30 cm/sec to 1.5 cm μsec. Special facilities for triggering from TV line or Frame pulses on IV.D.A.P. composite video waveform.
X Amplifier: gain 5, continuously variable.
Calibration: time and voltage calibration facilities.





MODEL 1049 INDUSTRIAL DOUBLE-BEAM OSCILLOGRAPH

Y Amplifier: A1: d.c. to 200 kc/s (—30%) at gain 900: A2: d.c. to 400 kc/s (—30%) at gain 30.
Time-Base: repetitive or triggered in 18 ranges, down to 7.5 sec/sweep.
Intensity modulation: three modes including beam bright-up.
Calibration: time and voltage, by calibrated shift (X and Y1) and multiplier (Y2).



MODEL 1035 GENERAL PURPOSE DOUBLE-BEAM OSCILLOGRAPH

Y Amplifiers: A1: 5 c/s to 5 Mc/s (—30%). Maximum gain 3,000. A2: 5 c/s to 250 kc/s (—30%) at gain 30, with trace inversion facility.
Time-base: repetitive or triggered in 9 sweep ranges from 100 msec to 10 μsec. Time-base delay and pulse bright-up facilities.
X Amplifier: gain 5, continuously variable.
Calibration: voltage and time, by calibrated shifts.

Let us send full details of Cossor Instruments or arrange for a representative to discuss your special needs.

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AUDIO AMPLIFIER STANDARD

Suitable for use as:

- ✳ *Laboratory Standard*
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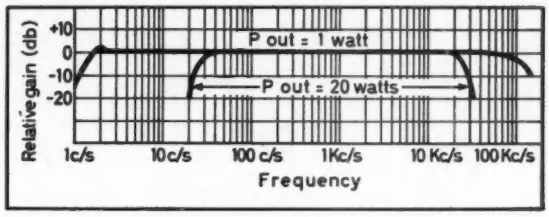
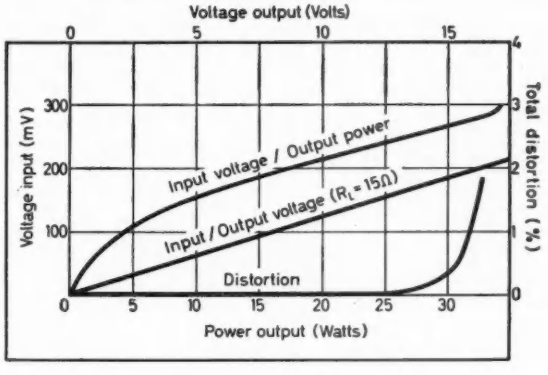
- ✳ *Recording amplifier.*
- ✳ *Broadcast Transmitter Modulator.*

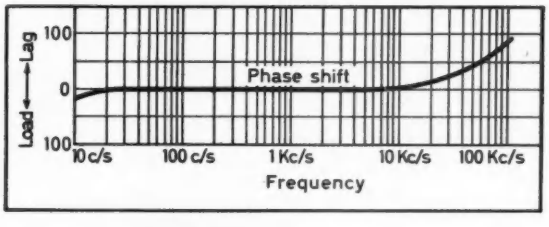
The Avantic DL7-35, originally designed as a high fidelity amplifier, has proved to be of such advanced design that it has remained unsurpassed. During the three years it has been manufactured the high performance laid down in the design has been consistently maintained. It can now be regarded as a Laboratory Standard of the utmost reliability.

AVANTIC DL7-35 POWER AMPLIFIER

Harmonic Distortion:
<0.05% at 20 watts sine wave output.
Intermodulation Distortion:
0.7% at 20 watts
1.0% at 29 watts
fm=40 c/s. fc=10 kc/s. fm/fc=4
Hum and Noise:
—85dB relative to 20 watts output with 10kΩ source resistance.
Distributed Load Push-Pull Output Stage.
Load Impedance:
4Ω, 8Ω, 16Ω switch selected with automatic feedback compensation.
Damping Factor:
50
Rise Time:
5μ secs.
Power Inputs:
105, 117, 125, 210, 233, 251 V. a.c.
40—60 c/s.







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Valve Voltmeters
Multi-range Testmeters
Valve Testers
and other electronic and nucleonic instruments

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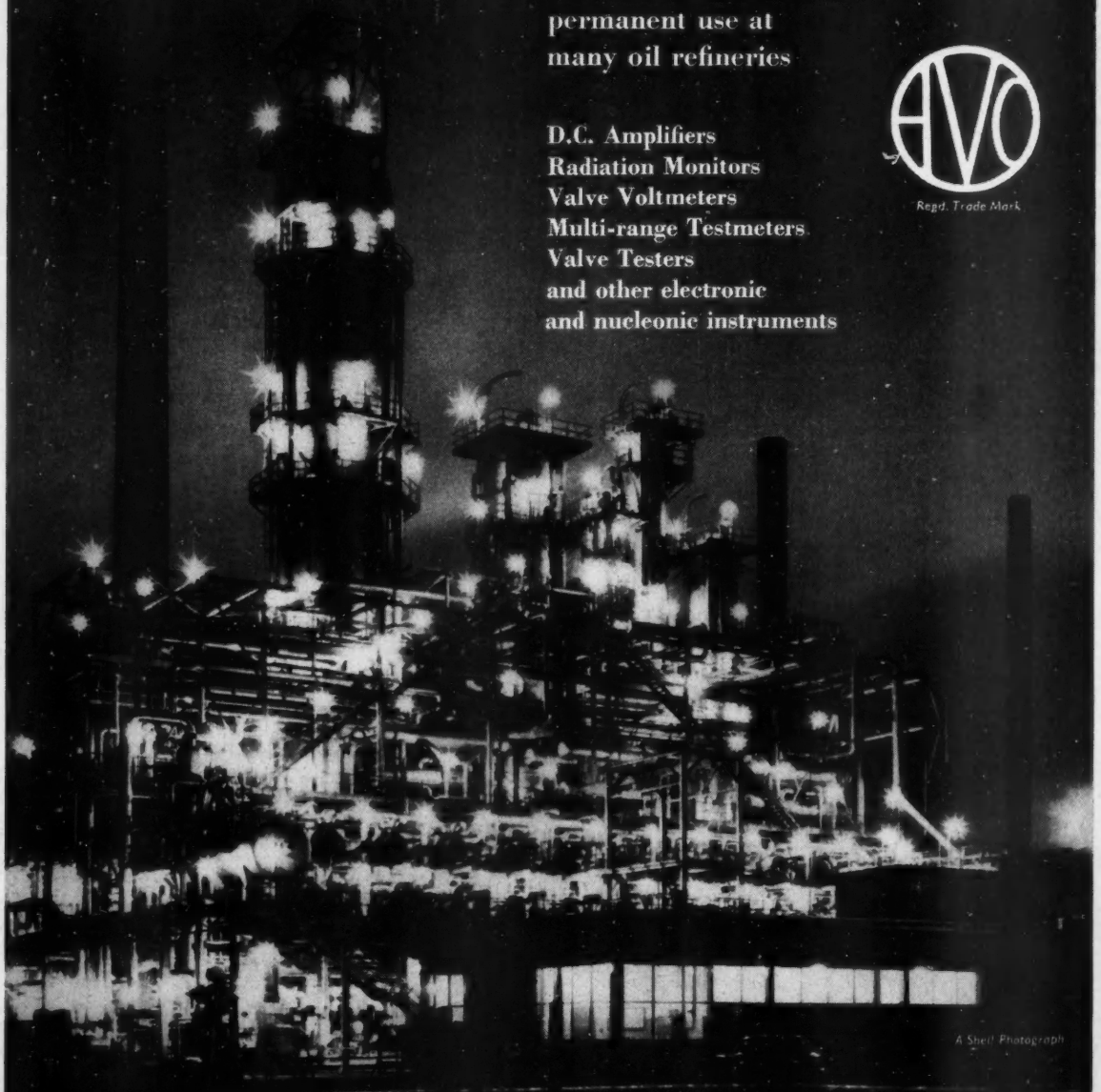

A Shell Photograph

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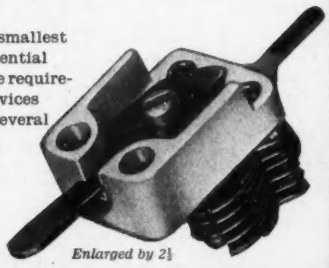
There can hardly be a need anywhere for an air dielectric of small dimensions that the Plessey range of robust miniature and midget trimmers will not meet, with precision and reliability.

These components are available in a variety of physical forms and capacitance values; their air dielectric and low-loss ceramic bases make them suitable for all VHF applications, while the 'C' type with silver plated vanes, is particularly appropriate for UHF.

The 'B' range includes types from 2 to 29 pF, the 'C' range from 2.3 to 8.5 pF. Every one of these trimmers is not only efficient, but will also withstand rigorous treatment, by bumping, vibration and climatic exposure—from —40°C to +100°C—with no loss in performance and dependability.

'C' Type Midget Trimmers

For use where the smallest dimensions are essential and designed to the requirements of Inter-Services Pattern C.V.A.8. Several versions are Type Approved and are being specified for various Ministry equipment.

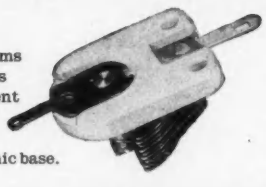


Enlarged by 2½

'B' Type Miniature Trimmers

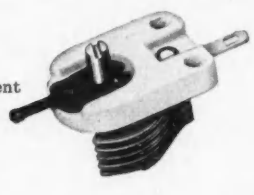
B.1 (180 series)

Preset model which conforms in general to Inter-Services Pattern C.V.A.7. Adjustment by screwdriver. Mounting by means of 6BA screws through two holes in ceramic base.



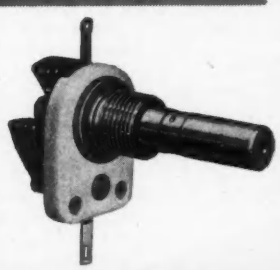
B.2 (170 series)

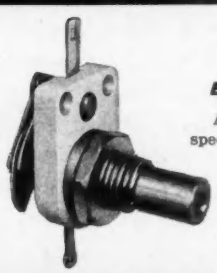
As B.1 but with adjustment at both ends.



B.3 (019 series)

For control knob operation with continuous rotation. Mounting by ⅜" 32 T.P.I. threaded bush. Spindle lengths to suit requirements.





B.4 (194 series)

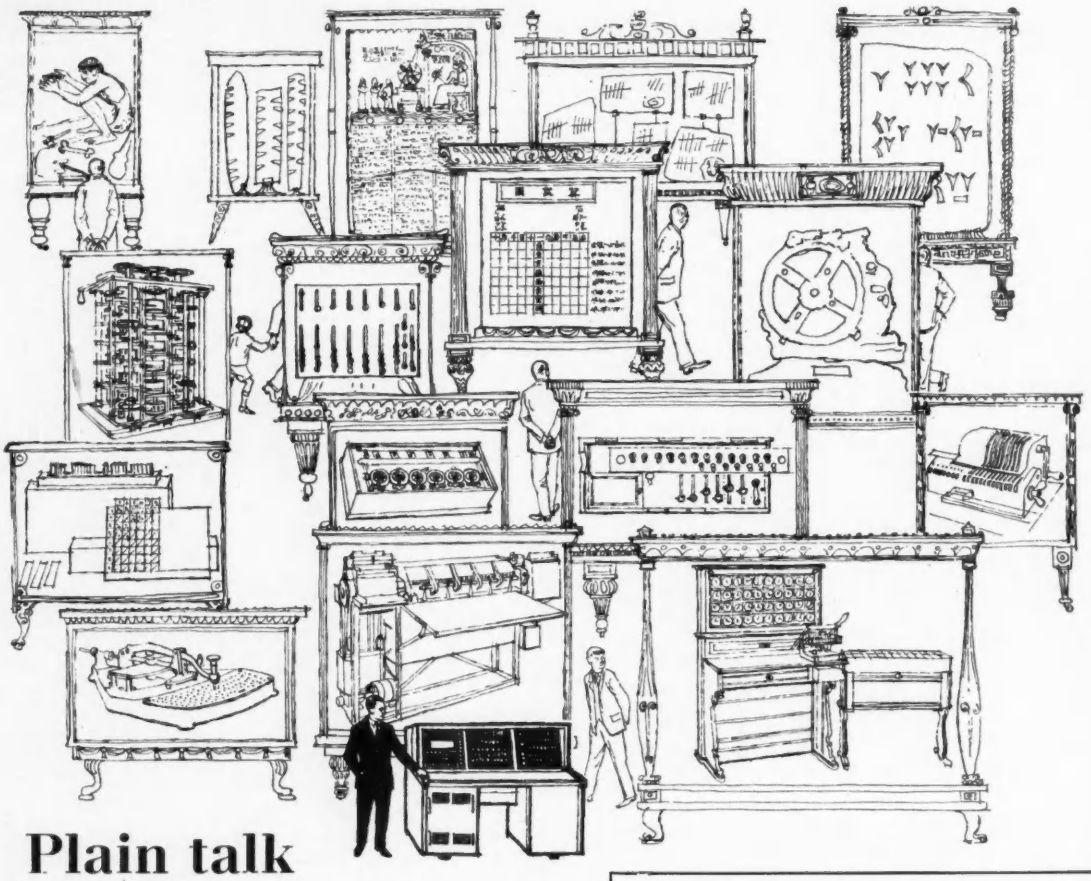
As B.3 but fitted with special bush and spindle to limit rotation to approximately 190°.

Plessey

COMPONENTS GROUP
THE PLESSEY COMPANY LIMITED
New Lane · Havant · Hants · Telephone: Havant 1701
Overseas Sales Organisation:
Plessey International Limited · Ilford · Essex · Tel: Ilford 3040

HC4

EE 15 042 *for further details*



Plain talk about data processing

From the time the first man stood on his hind legs and counted on his fingers, he has been using the best data processing system of all, the one in his cranium. He stored up his information and when he was faced with a problem he consulted his records and used them to decide on the right course of action. As his affairs grew more complicated and he turned into a business man he tried very hard to predict things to come. But the cold truth is, as he discovered when his crystal fogged over, the only real way to predict the future is to reconstruct the past and to study it in relation to present facts and future trends. Facts and figures are needed in accessible form, and that's what modern data processing does for him. It also takes a great load of drudgery off his shoulders (and the shoulders of his staff).

I·C·T

Plain talk about I·C·T

You do not have to be a big business to use I·C·T data processing equipment. The range is so wide — computers, electronic calculators, punched cards — that it is being used in businesses of all sizes, from huge undertakings like British Railways to small companies employing less than 20 people.

I·C·T service begins with your enquiry. Alongside your own executives, I·C·T specialists will study your business to see if I·C·T data processing equipment will help you. If it will they'll give you a detailed report of their recommendations and their economics, specifying equipment to meet your exact needs. I·C·T trains your staff, and special courses ensure your executives gain the background knowledge to make the equipment earn every penny of its keep. The same service sets the installation on its feet and is available to you throughout its life.

This is I·C·T service using all the resources of Hollerith and Powers-Samas, two pioneers of data processing.

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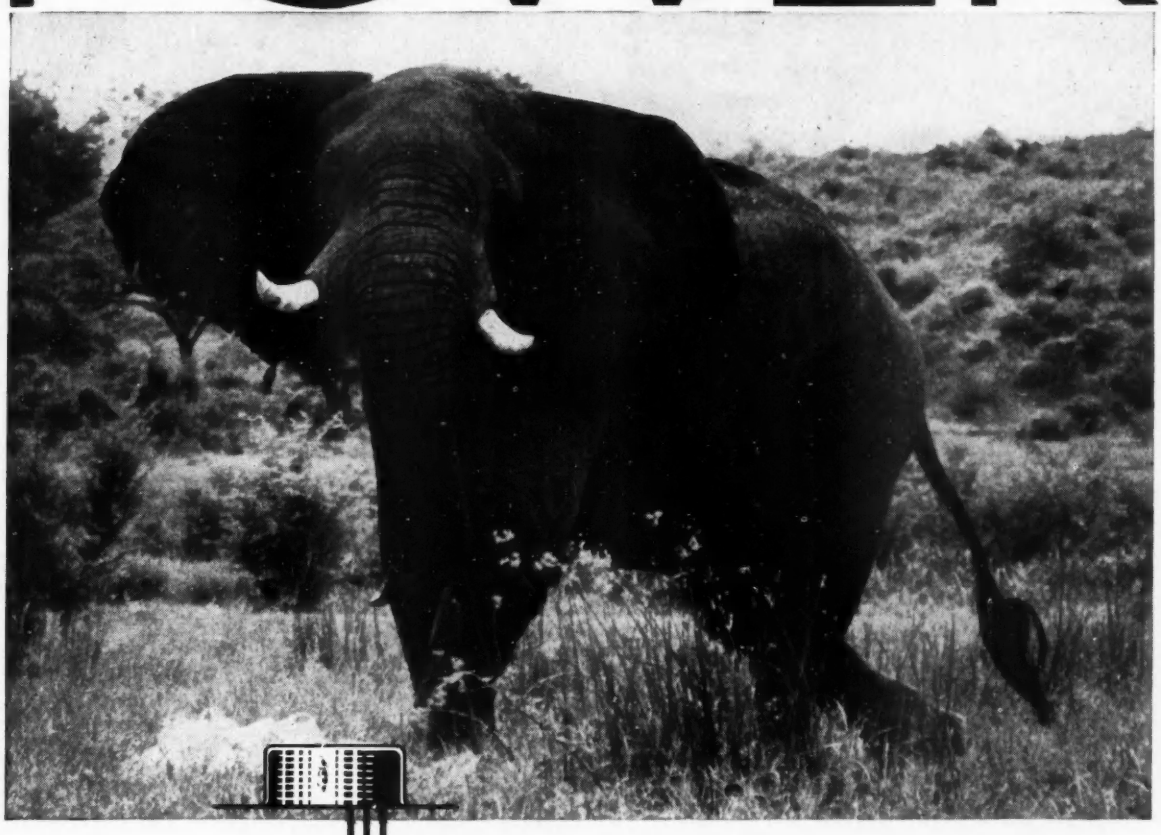
HEAD OFFICE: 149 PARK LANE, LONDON, W.1 HYDE PARK 8080. OFFICES THROUGHOUT THE U.K. & OVERSEAS

EE 15 043 *for further details*

POWER



12A POWER TRANSISTOR ...another G.E.C. first!

GET57 Series
G.E.C. have produced a transistor capable of switching up to 12A in d.c. converters or giving 50W output from a class-B push-pull audio amplifier at 45°C. Extremely robust and reliable, these transistors are suitable for use in power amplifiers, servo amplifiers, d.c. converters and many similar applications. Matched pairs are available.

TYPE	Maximum Ratings					Typical Characteristics		
	Peak collector current $i_{c(pk)}$ (A)	Peak collector-base voltage $v_{cb(pk)}$ (V)	Peak collector-emitter voltage (base open-circuited) $v_{ce(pk)}$ (V)	Thermal resistance (Junction to cooling system) (°C/W)	Junction temperature $T_{j(w)}$ (°C)	Large signal current gain h_{FE} (V_{ce}=−1.5V, I_c=12A)	Base-emitter voltage V_{eb} (V) (V_{ce}=−1.5V, I_c=12A)	Collector-emitter voltage V_{ce} (mV) (I_c=12A, I_b=2A)
GET571	12	16	16	2.5	90	15	1.0	160
GET572	12	32	32					
GET573	12	64	40					

G.E.C.

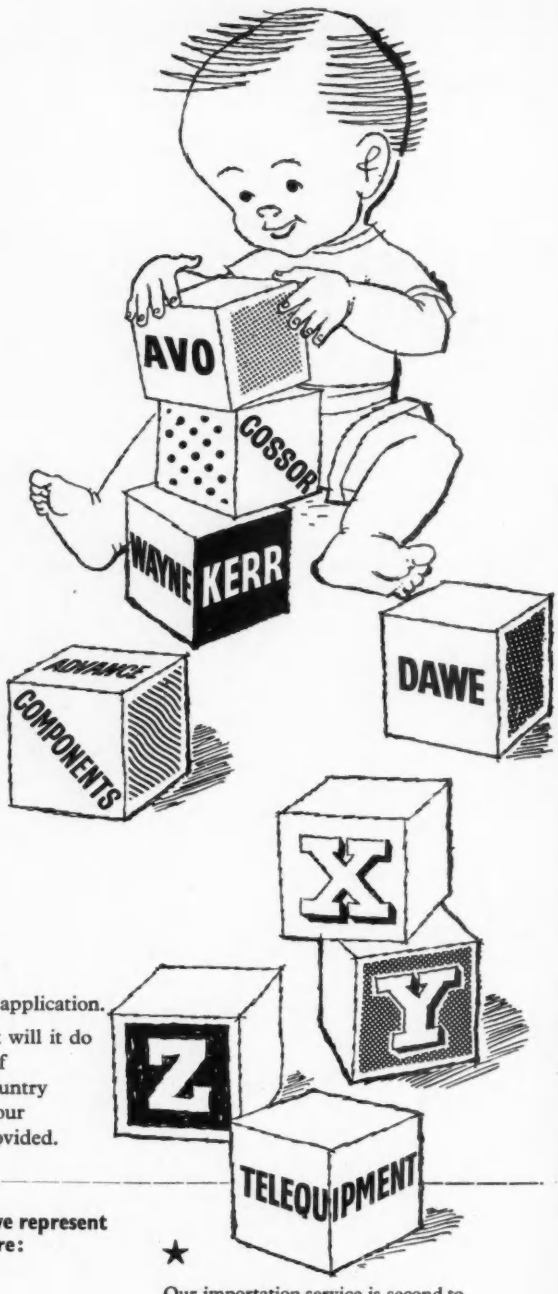
SEMICONDUCTORS

For full information on these and other devices please contact:
G.E.C. Semiconductor Division, School Street, Hazel Grove,
Stockport, Cheshire. Tel: Stepping Hill 3811
or for London area, ring Temple Bar 8000, Ext. 10.

EE 15 044 *for further details*

We've built a service from A to W,

(X, Y, Z, will follow no doubt)



We hold stocks of many British instruments from leading makers. Our association with British manufacturers from (alphabetically speaking!) Advance to Wayne Kerr goes back many years and we maintain a comprehensive index and technical information service covering the electronic instruments of the world.

OUR FIRST CONSIDERATION—the *right* instrument for your application. The relevant factors are not who makes it or where it is made, but will it do the job. At Retcar Street you can discuss the technical problems of instrumentation and the new techniques developed both in this country and abroad. If it is impossible to call—write or telephone about your particular problem or requirement and full information will be provided.

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METER SCALE CALIBRATED IN VOLTS AND dB

CAN BE USED AS A NULL DETECTOR AND INDICATOR FROM 10c/s to 10Mc/s

CAN BE USED AS AN AMPLIFIER FROM 10c/s to 10Mc/s

INCORPORATES ITS OWN H.T. STABILIZER

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at this price . . .

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with this backing . . .

Behind this, the most modern instrument in its sphere, is that specialist instrumentation skill and experience which has earned for all 'Advance' products a reputation second to none throughout the Industry. From our up-to-the-minute factory at Hainault comes this latest addition to the world-famous 'Advance' range of instruments.

Full Technical details of the 'Advac' in Leaflet M50

THE Advac

Size : 4¾" x 7½" x 6¾"
Weight : 7 lb.

Advance COMPONENTS LIMITED
INSTRUMENTS DIVISION
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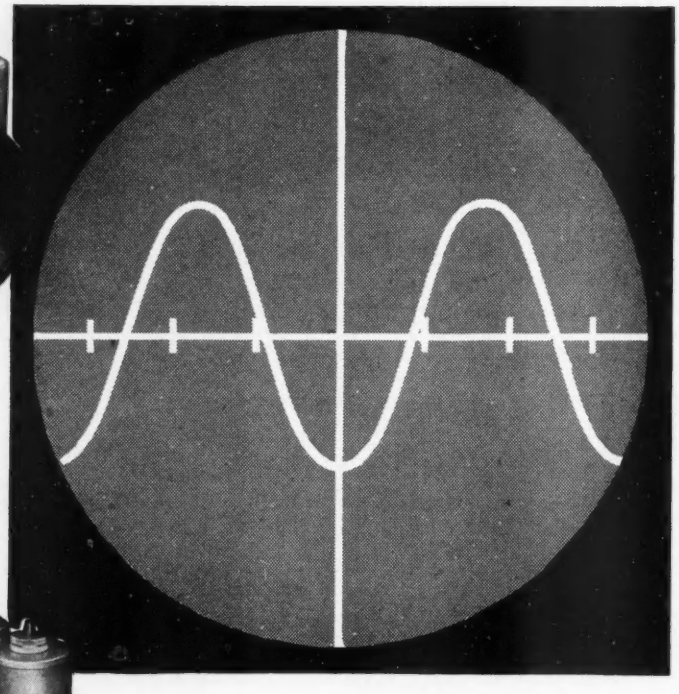
GD.64

EE 15 046 *for further details*

INSTRUMENTS FOR INDUSTRY

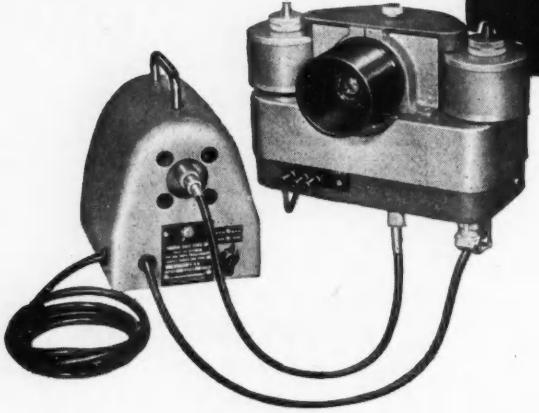
OSCILLOSCOPE CAMERAS

JLT Oscilloscope Cameras have been designed to provide permanent records for engineers in industry and research laboratories. They are precision instruments capable of producing results of the highest standards.
A range of hoods and adapters is available which enables these cameras to be used on most general purpose oscilloscopes now on the commercial market.



SERIES 100

This camera has been designed for single shot recording of recurrent waveforms or transients. Simple in construction, robust and of good appearance, it will produce excellent photographic records using standard 35mm. cassettes with a capacity for 40 exposures.



SERIES 200

Designed for both single shot and continuous feed recording of cathode ray tube traces, the Series 200 has a motor built into a separate unit and connected to the camera by a flexible shaft. The equipment is therefore adaptable to special applications and can be used with various electrical supplies.

JLT GROUP

J. LANGHAM THOMPSON LTD.

BUSHEY HEATH · HERTFORDSHIRE
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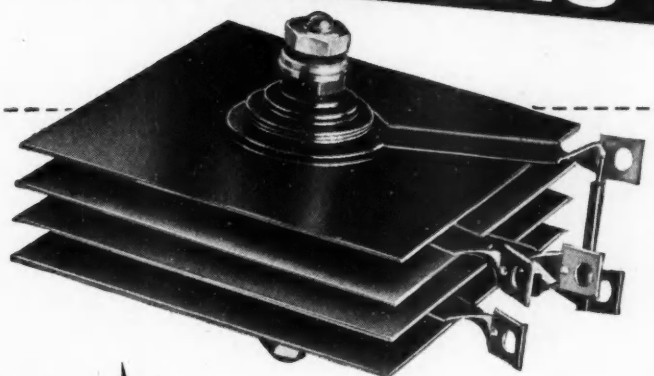
AD/C18

SEMICRON

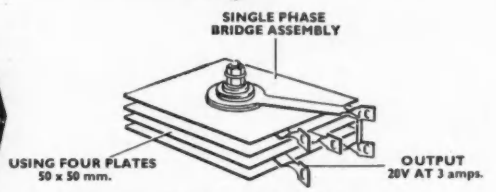
SELENIUM RECTIFIERS

LOWER FORWARD RESISTANCE
HIGHER BACKWARD RESISTANCE



HIGHER CURRENT DENSITY PER PLATE THAN ANY OTHER SELENIUM RECTIFIER ON THE MARKET

E.G.



* **THIS IS A TYPICAL EXAMPLE OF SEMICRON EFFICIENCY**
If the plate size of the above rectifier is increased to 100 x 100 mm the output would be 20V at 10 Amps.

Semicron Selenium Rectifiers have many applications in commercial electronic and electrical equipment including: Telecommunications equipment, Power Supplies, Elevators, Electric Trucks and Lifting Devices.

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AD/S18

Frequency measurement up to ***1 Mc/s***

– for less than £300

and time measurement into the bargain!

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VENNER Electronics

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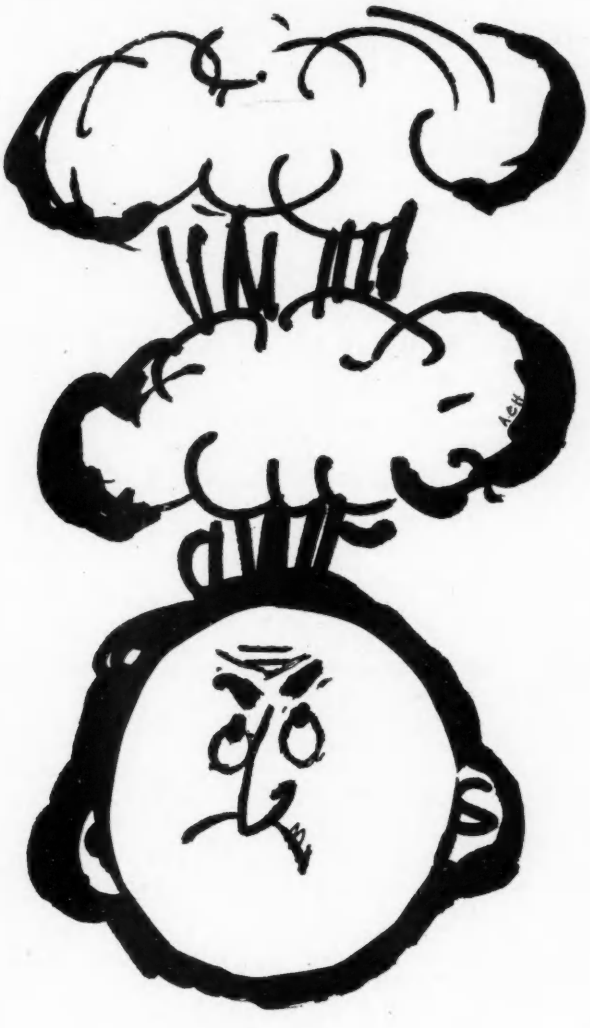
Don't blow your Top!



It can be exasperating when you're doing your best to build to a size, a price or a performance figure and some obstinate component keeps beating you. But wait, keep calm, isn't there just a chance that PTFE might be the answer? Tough, non-corrodable PTFE with its complete freedom from tracking and its low dielectric constant, power factor, dielectric strength and wide temperature range. If there's a hope that PTFE might be the answer, leave it to us to find out. We have the facilities and the experience. We use PTFE in many of our own products, and we process, mould, extrude, machine and fabricate it for other manufacturers. We have stopped quite a lot of tops from being blown by using PTFE in components like valve and cathode ray tube holders, insulators, co-axial connectors, wave guide windows and instrument wire sheathing. Write for our booklet about it.

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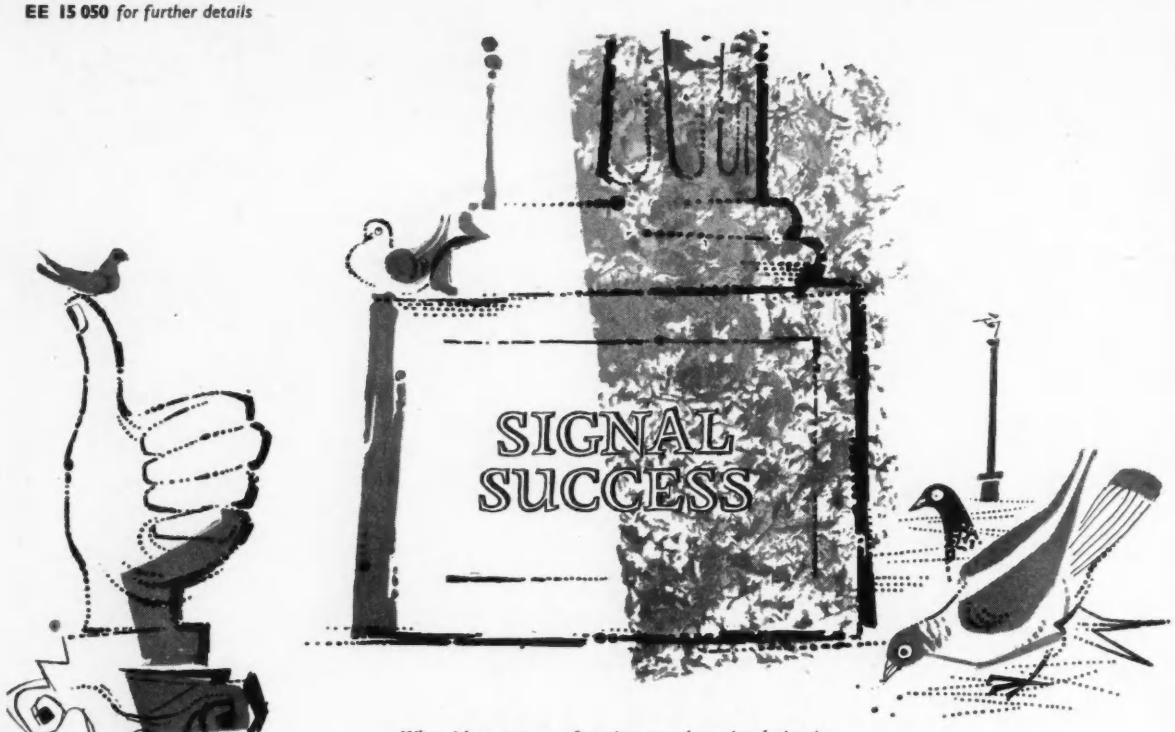

When it's a matter of testing sound or visual circuits, the stability of the input signal is of paramount importance. In this the Wayne Kerr Audio Signal Generator S121 and Video Oscillator O22B are outstandingly reliable, enabling the quality of the tested circuits to be gauged with the highest degree of accuracy.

The Audio Signal Generator is a high grade laboratory instrument, with a range of 10 c/s to 120 kc/s. It is stable to within 0.2dB over the entire frequency range and has a particularly low level of distortion. Further, it is a direct reading instrument and is compact, light in weight and portable. The precision and practicability of this instrument have been acknowledged by the Armed Services, for whose use it is approved under the reference CT417.

The Video Oscillator is accurate to within ±1% and provides an output within the frequency range 10 kc/s to 10 Mc/s. This top quality instrument has a particularly stable output and low level of distortion.

Indispensable elements in all development laboratories, and used extensively by communication authorities, signal sources are essentially instruments of which the accuracy and reliability must be assured. For these reasons more and more electronic engineers are putting their trust in Wayne Kerr Audio Signal Generators and Video Oscillators.

WAYNE KERR

Audio Signal Generators and Video Oscillators

The Wayne Kerr Laboratories Ltd.,
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WK6

'C' CORES for *open-type* TRANSFORMERS

'ENGLISH ELECTRIC', with many years' experience in the manufacture of transformers of every type and size, have developed 'C' cores for small transformers and chokes. These cores comply with the requirements of the Standard Inter-Service Range (RCL 193).

The full range of 'C' cores in ·013″ and ·004″ strip is available from stock and special sizes can be wound to order. Cores can also be supplied wound from ·002″ and ·001″ strip. Their use results in smaller, lighter and more efficient transformers and chokes. Accessories are also supplied so that manufacturers can order *all* transformer requirements from 'ENGLISH ELECTRIC'.

5 ADVANTAGES OF 'ENGLISH ELECTRIC' 'C' CORES

- ★ Cores are easy to store, easy to handle and result in reduced transformer assembly time.
- ★ The complete transformer is up to 30% smaller and lighter.
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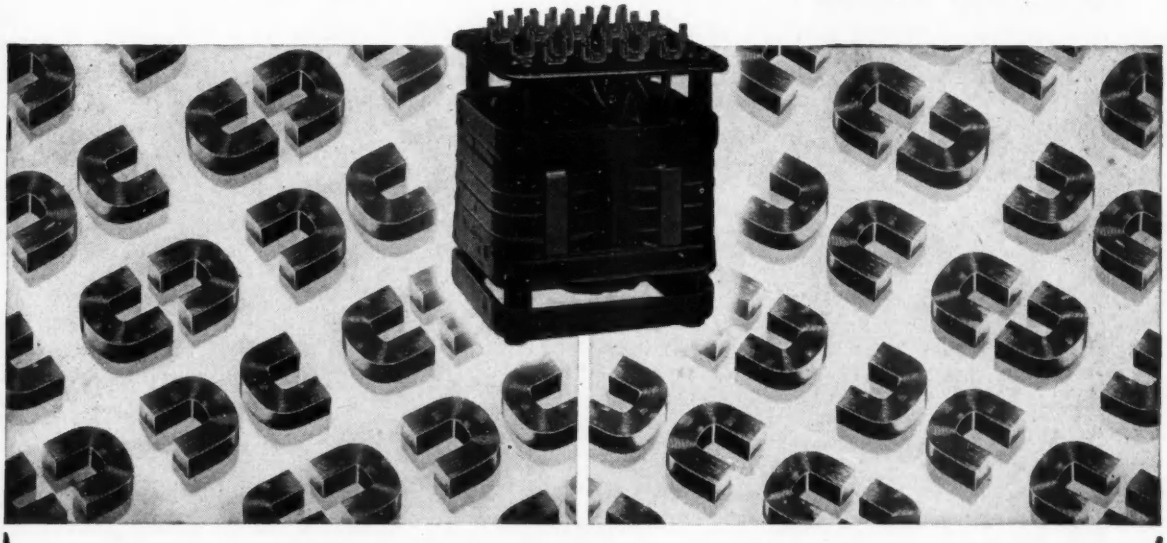
- ★ Cores are suitable for oil-filled, open-type or resin-cast transformers.

Send enquiries, or for publication TF/239, to The English Electric Company Limited, Transformer Sales and Contracts Section, East Lancashire Road, Liverpool, 10. Telephone: Aintree 3641.



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Britain's leading manufacturers of 'C' cores

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

TFL. 38

MARCONI VACUUM-TUBE VOLTMETER TF1041B - *for u.h.f precision*

For unprecedented performance and versatility

The Marconi TF 1041B is a versatile, precision voltmeter offering an unprecedented performance in the measurement of a.c. voltage, d.c. voltage, and resistance.

For a.c. measurement the frequency range extends from 20 c/s to 1,500 Mc/s and the voltage range from 25 mV to 300 volts; input capacitance is only 1.5 μμF and input resistance is 0.5 MΩ at 10 Mc/s.

The d.c. measurement range is 10 mV to 1,000 volts and input impedance is 100 MΩ; the meter can be switched to give forward deflection for positive or negative voltages, or to allow centre-zero measurements.

Resistances can be measured from 0.02Ω to 500 MΩ.

Optional accessories include multipliers for up to 2 kV a.c. and 30 kV d.c., a T-connector for measurements on co-axial lines, and a wide-band coaxial dummy load. Send for leaflet J163.

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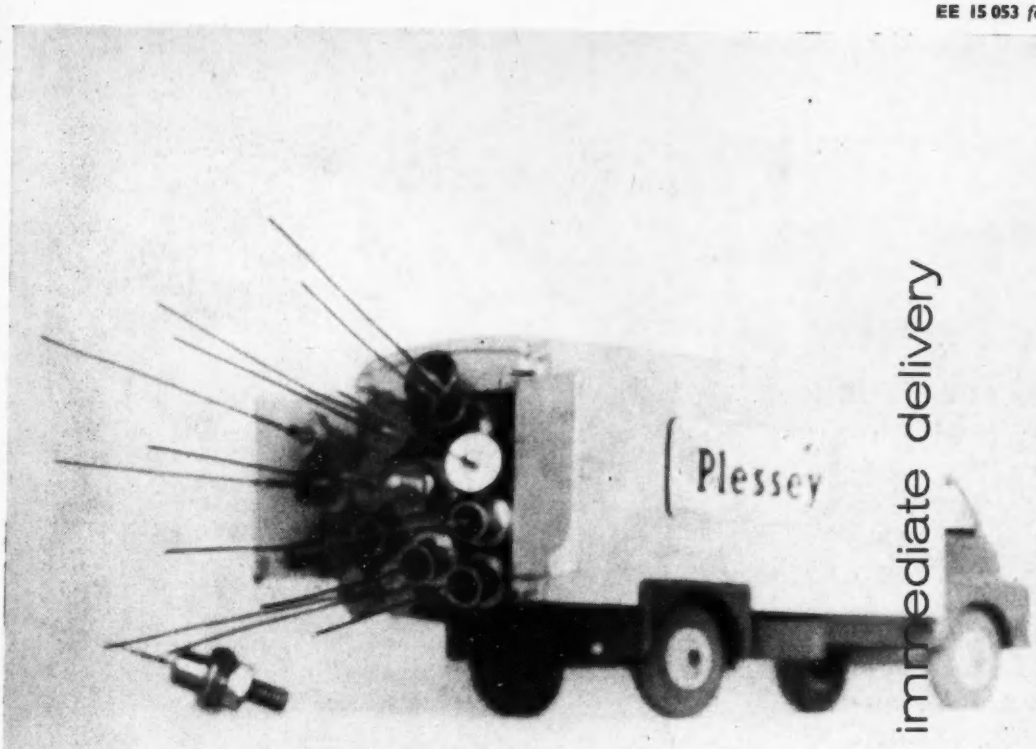
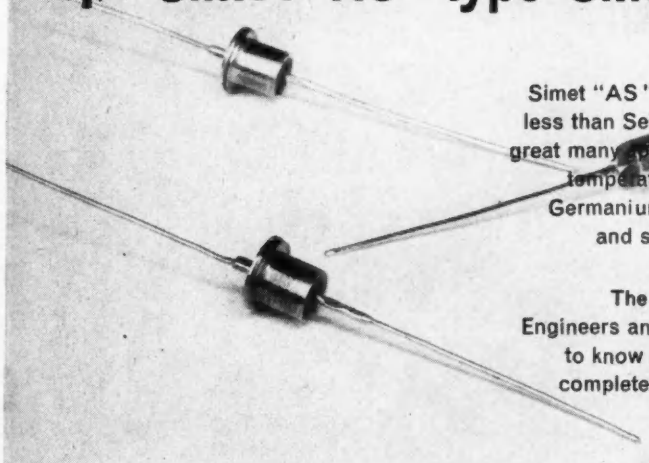
TC 163



immediate delivery

✱ Simet "AS" type Silicon Rectifiers



✱ and this isn't all.
Simet "AS" type Silicon Rectifiers cost less than Selenium and valve types for a great many applications, operate at higher temperatures than both Selenium or Germanium (up to 150°C), do not age, and show savings in weight, bulk and total cost.

The range is extended to 800 P.I.V.
Engineers and Designers who would like to know more are invited to write for complete data . . . and . . . deliveries, remember, are immediate.

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EE 15 054 *for further details*

The man who's using AUSTINLITE without knowing it

Any man in the know rings up Austinlite when he wants something slightly—or considerably—out of the ordinary in electrical control gear. In doing so it is almost a certainty that he is depending on Austinlite for his connection: the G.P.O. uses hundreds of Austinlite standby sets and control cubicles.

So do other public services. In fact wherever control gear must be more than usually reliable you tend to find it is made by Austinlite. Not surprising really. Austinlite gear was in its early days developed for use in lighthouses. Millions of tons of shipping depend on . . .

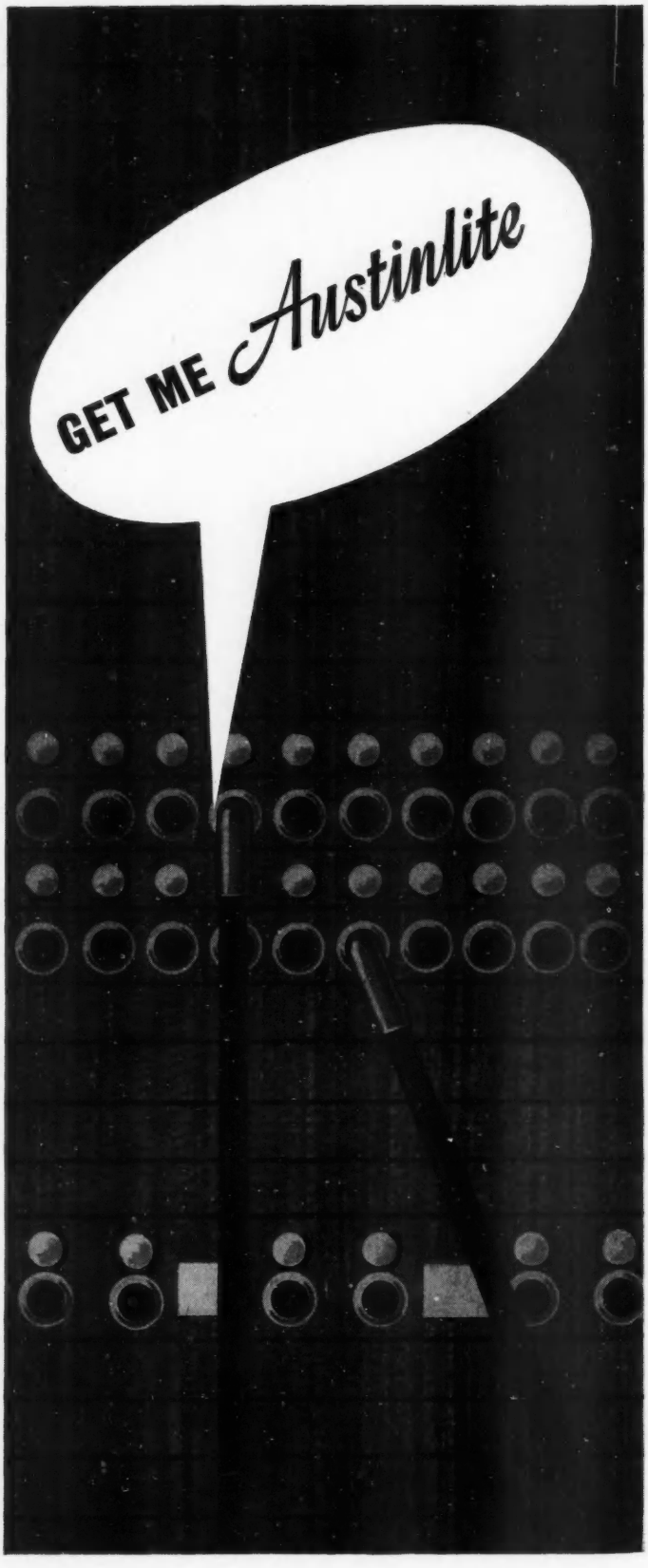
Austinlite

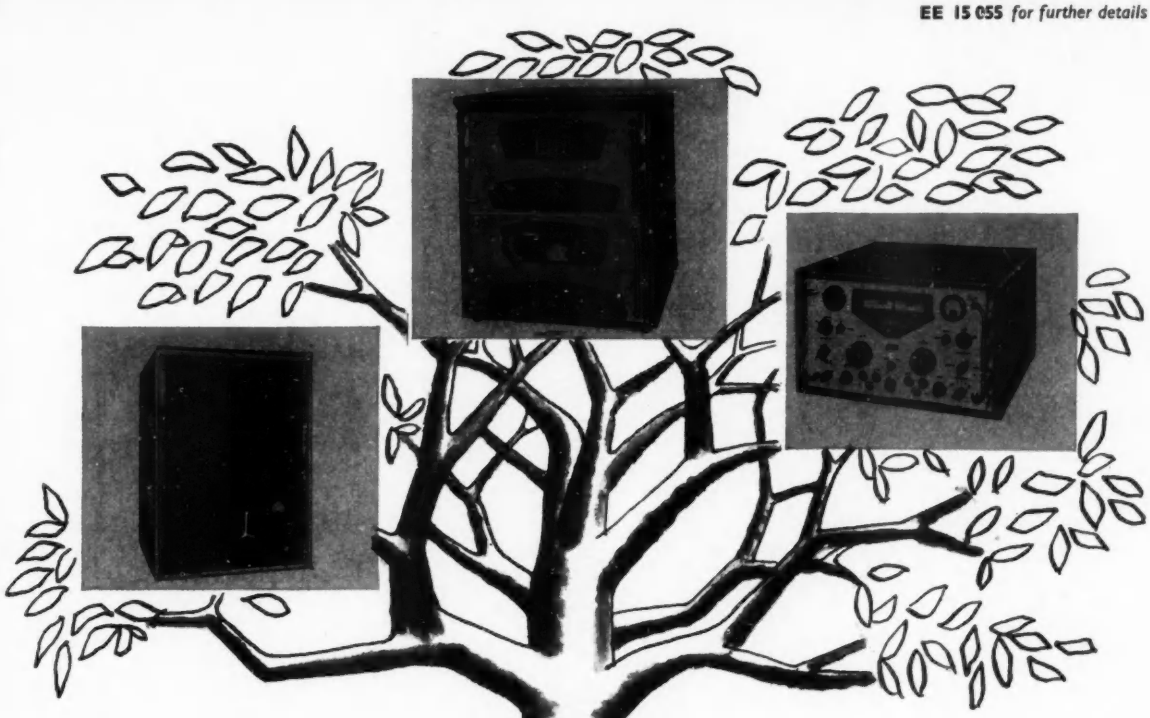
ELECTRICAL EQUIPMENT
Custom-built by
STONE-CHANCE LTD.

(Makers of Sumo Pumps and Stone-Chance Lighthouses)

CRAWLEY, SUSSEX, ENGLAND

London Office: 28 St. James's Square, S.W.1.
Telephone: TRAfalgar 1954.





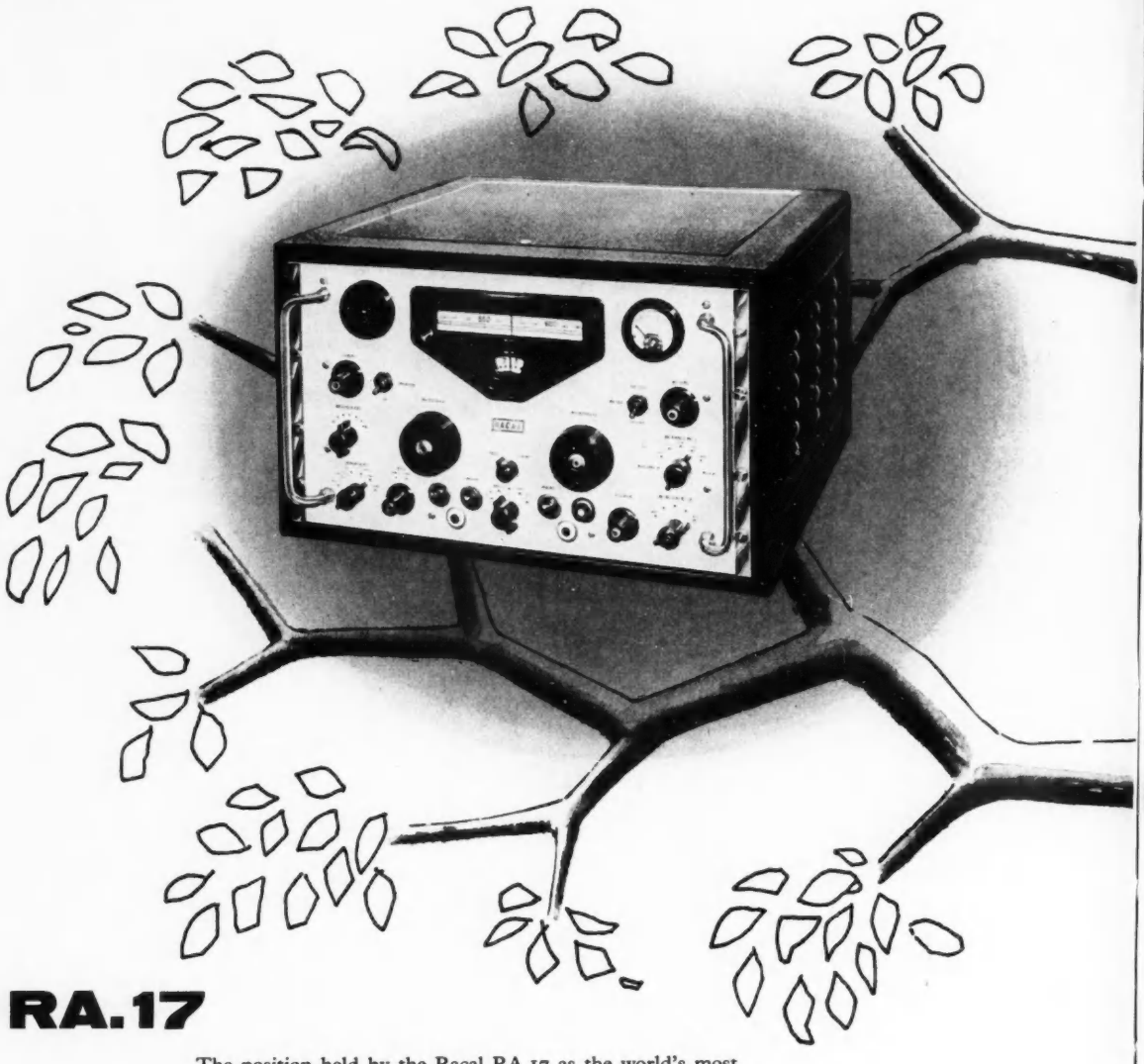
"... From little acorns ..." perhaps it is a little early to say that a mighty oak has grown. But certainly we show nearly ten years of sturdy growth. Racal's products for the HF communication field, particularly the RA.17 receiver with its associated developments and the growing range of SSB equipment, represent an achievement of which any Company could be proud.

Our large modern factory at Bracknell—to which have recently been added new laboratories and sales offices—is turning out an ever-increasing flow of equipment to meet the demands of industrial customers and government organizations all over the world. These few pages can give only a brief summary. If they interest you, write for further details.

RACAL

Engineering Limited

BRACKNELL BERKSHIRE ENGLAND



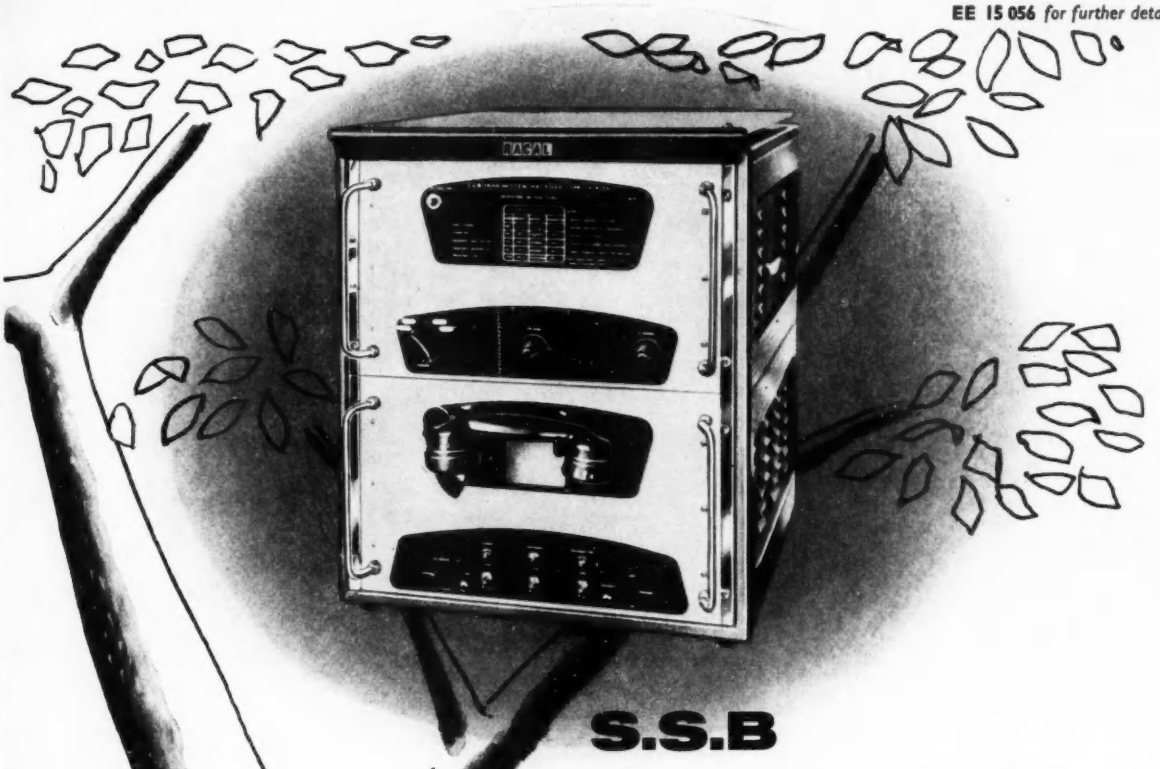
RA.17

The position held by the Racal RA.17 as the world's most outstanding HF communications receiver is being further improved by the introduction of new specialized versions and ancillary equipment.

The simplicity of these units is derived largely from the basic design of the RA.17 receiver which provides first-class stability, high sensitivity and an amazing setting accuracy. Sales of the receiver are approaching the 3,000 mark with large numbers delivered to customers in the United States and Canada, not to mention the other discerning radio organizations in nearly every corner of the globe.

RACAL ENGINEERING LIMITED

EE 15 056 *for further details*



S.S.B

the radio communications system of the future

The Racal transmitter and receiver range brings the outstanding advantages of SSB communication to all users of HF radio links. Simplicity and reliability of operation are major features of each design. Most of the units are easily transportable and all are especially suited for overseas use and for operation by unskilled personnel. The TRA.55 60 watt radio telephone is shown here and on this month's front cover. Other models available so far include the TA.83 and TA.104 (500 watt and 60 watt) transmitters and the TA.99 and TA.84 (1kW and 5 kW) linear amplifiers. The RA.87 and RA.101 SSB receivers offer a first-class complement for these units. Further additions to the range will be announced very soon.

RACAL ENGINEERING LIMITED

EE 15 057 *for further details*

Digital instrumentation

In the field of production line and laboratory instrumentation where great speed and an exceptionally high degree of accuracy is required in control, direct counting and data handling, Racal have been in the lead with the many applications of their Digital Counting Instruments. The digital counter is already regarded as a 'must' in many industrial control systems and processes and Racal provides a comprehensive range of such equipment. Racal's many years experience in the design and construction of digital instruments and their application in frequency measurement, pulse counting, timing and data handling field are gladly offered to the design engineer of laboratory, control and production equipment.

RACAL Instruments Limited

WESTERN ROAD, BRACKNELL, BERKS, ENGLAND Tel.: Bracknell 941 'Grams/Cables: **RACAL BRACKNELL BERKS**

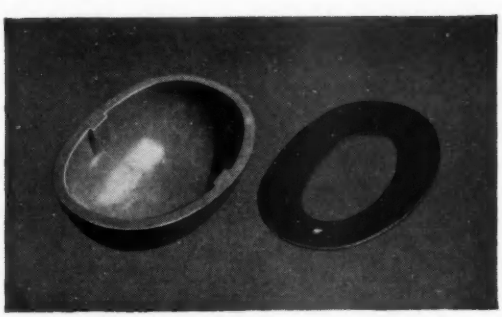
Overseas agents in most territories

Here's a typical example of how the mechanical strength of Beetle D.M.C. (Dough Moulding Compound) helps to solve industrial problems.

These ear defenders are used to protect the hearing of workers in proximity to jet engines and in noisy factories. During the development work by the makers, Dennis Ferranti Meters Ltd., twelve sets moulded from conventional materials were delivered to Bomber Command for testing. The report of The Central Medical Establishment, Acoustics Laboratory, was that the ear defenders gave excellent protection, but that the mouldings then used were considered too fragile.

D.M.C. mouldings were substituted and have been found virtually indestructible.

D.M.C. is the ideal material whenever high mechanical and/or electrical strength is required. The material can be moulded in conventional compression presses on short cure times and at low pressure. We shall be glad to send full technical details.



This illustration shows the main moulding from Beetle D.M.C. and a retaining piece made from Scarab material. The Earguards are used in engine testing, riveting, blasting, rolling mills, weaving sheds, paper mills and on aerodromes.

B·I·P

BEETLE MOULDING POWDERS

B.I.P. CHEMICALS LTD., Oldbury, Birmingham. Telephone: Broadwell 2061.
London Office: 28, Haymarket, London, S.W.1 Tel: Trafalgar 3121

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DIGITAL VOLTMETERS

- Decimal in-line display.
- All electronic — new counting tube.
- ±0·05% and ±0·1% accuracy.
- 13 milliseconds or 103 milliseconds conversion time. 3 read-outs per second.
- Automatic range and sign selection with indication.
- 500 Kilohms minimum input impedance.
- Integral in-line printer drive.

These all electronic digital voltmeters, using an entirely new counting tube, have been designed for application in fields requiring accurate measurements of D.C. voltages. These include computer inputs and outputs, reference supply measurements, strain gauge measurements, production testing of electronic and electrical components and industrial process control, (e.g., analogue-to-digital conversion).

BLACKBURN ELECTRONICS LIMITED

BROUGH · YORKSHIRE **TELEPHONE BROUGH 121**

BE

A complete packaged drive service for industry

The New Light Duty PowerGrip Range has been designed for drives from fractional H.P. to 5 H.P. and is supplied ready packaged from stock for immediate fitting on to your machine. The drive is completely positive and non-slip and has an efficiency of virtually 100%. It is stretchless, needs no lubrication and is extremely compact. Ideal for driving small tools and light machinery.

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Distributors in the United Kingdom and Northern Ireland

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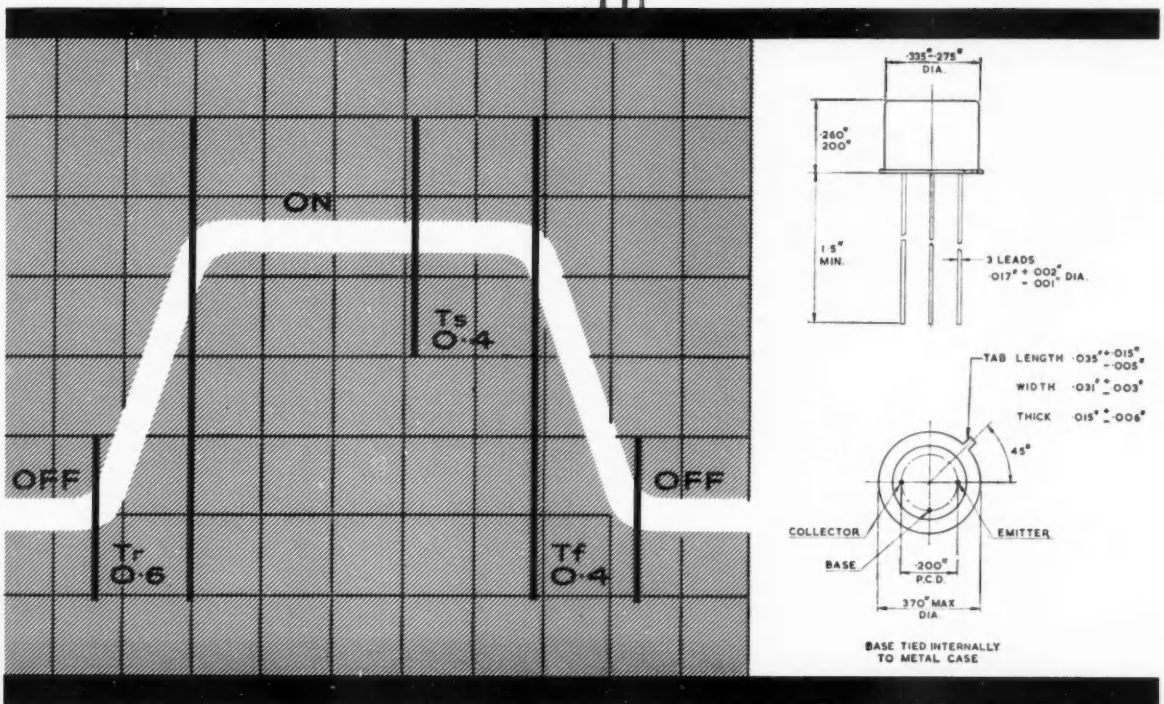
SYLVANIA-THORN MEDIUM AND *HIGH SPEED* NPN SWITCHING TRANSISTORS

which switch in tenths of microseconds

Each type in the line is designed especially for computer and switching applications. They feature close control of current gain and frequency cut-off and are especially adaptable to high temperature use.

These medium and high speed switching transistors are widely used because of their outstanding reliability and stability. Each type is subjected to 100% leak tests and stabilising tests to assure top performance under the toughest operating conditions. Each type is encased in a standard package with the Sylvania-Thorn welded hermetic seal for full protection against humidity and severe environmental conditions.



WRITE FOR FURTHER DETAILS TO

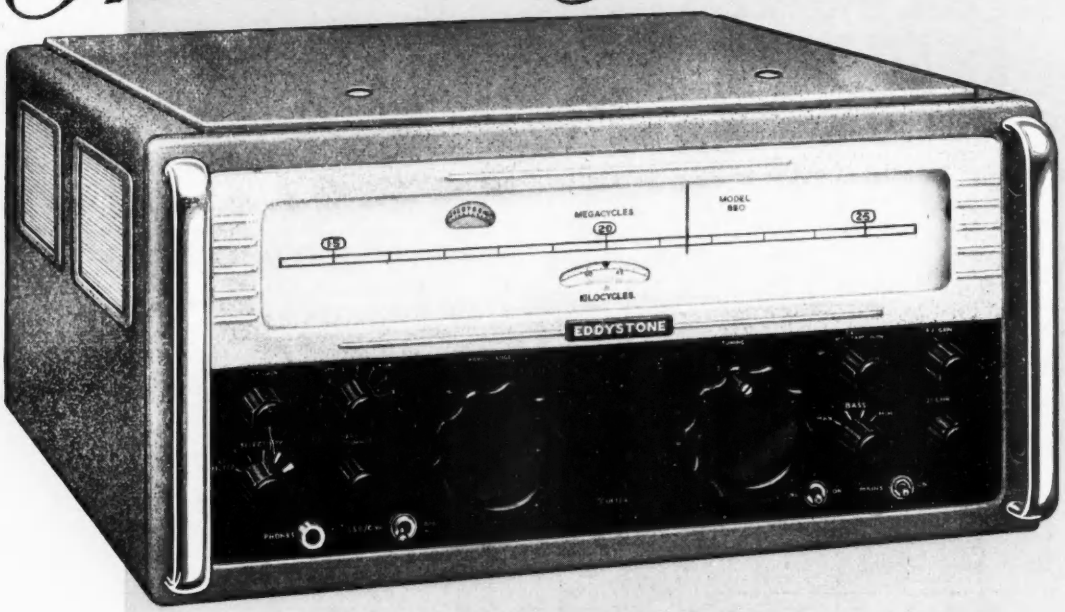
SYLVANIA-THORN

COLOUR TELEVISION LABORATORIES LIMITED
DEPT. ST2. GT. CAMBRIDGE ROAD
ENFIELD, MIDDLESEX

SYLVANIA-THORN MEDIUM AND HIGH SPEED NPN SWITCHING TRANSISTORS

Type	Collector to Base V.	Emitter to Base V.	Power Diss.	Frequency Cut off, fab Vcb=6v. Ic=1ma min.
2N377	25v	15v	150mw	2.5mc
2N385	25v	15v	150mw	4mc
2N388	25v	15v	150mw	5mc
2N377A	40v	15v	150mw	2.5mc
2N385A	40v	15v	150mw	4mc
2N388A	40v	15v	150mw	5mc
2N679	25v	15v	150mw	2mc

Introducing—



—the EDDYSTONE '880'

High Stability Communications Receiver

The Eddystone "880" High Stability Communications Receiver, now in the production stage, reaches high modern standards. It has been designed expressly for use in professional communications systems and, with the many refinements provided, is widely versatile in its applications.

The principle employed results in an exceptionally high degree of frequency stability. Throughout the tuning range of the receiver, which is from 500 kc/s to 30.5 Mc/s, the long term drift does not exceed 50 cycles. Particular care has been taken to reduce spurious responses to an absolute minimum and the figures for such characteristics as cross-modulation, blocking, inter-modulation and image ratio are extremely good. The electrical performance is well maintained in every way and conforms to accepted professional standards.

There are two fully tuned r.f. stages and all tuning is accomplished with a single knob. The tuning rate is linear and the large clear scale shows only the range in use. The frequency can be set to within one kilocycle. Radiation at any frequency has been reduced to a very low figure. Comprehensive information and full specification available on request to commercial and professional concerns.

RADIO PRODUCTS EDDYSTONE TRADE MARK

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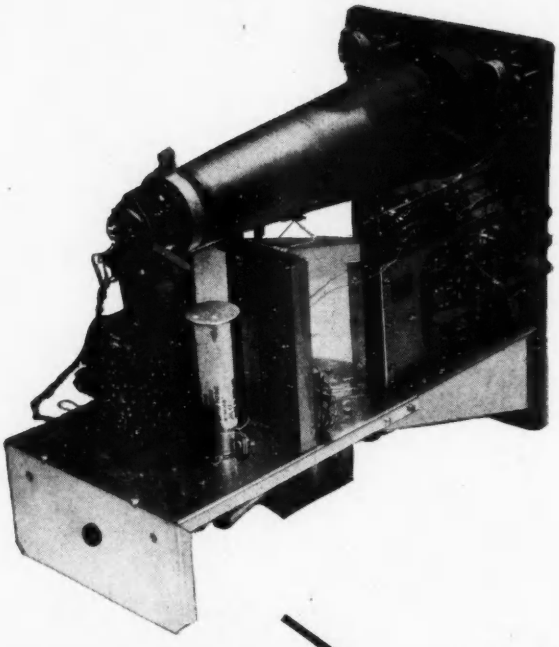
with
an eye
to
voltage...



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For example, the Kit Double-Beam Oscilloscope by *Cossor*
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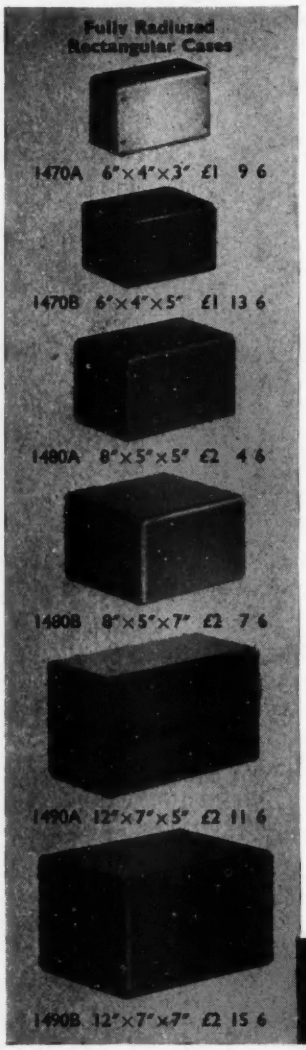
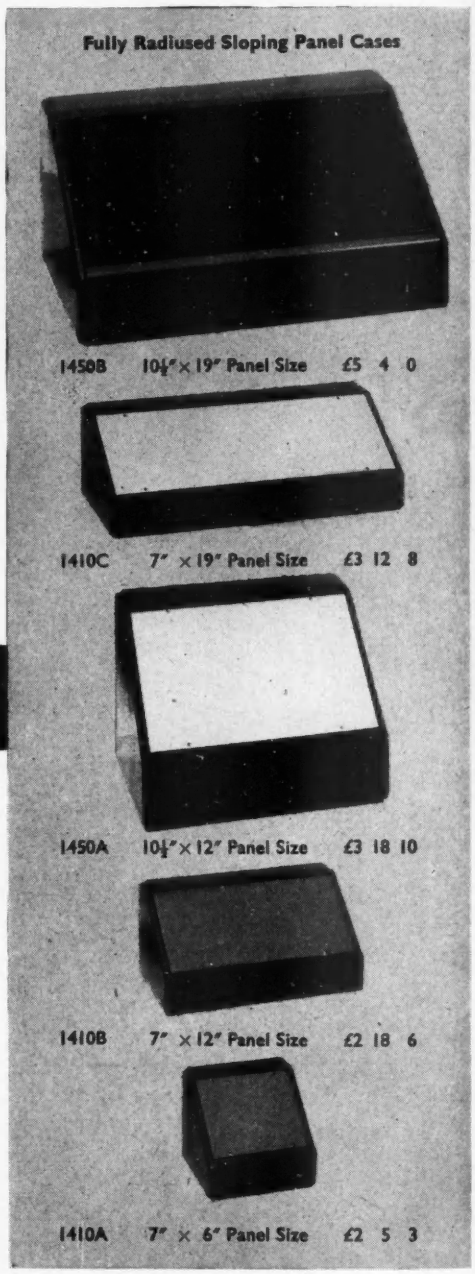


new small and miniature standard cases at really *LOW PRICES!*

15 new Imhof standard cases with panel sizes from 6"×4" to 24"×10½". Just look at these examples . . . compare the new low prices. Here's real value for money! Whatever the size —whatever the quantity—all these new cases are built to the same, robust specification and high finish as the existing Imhof Standard Range. Top quality and rock-bottom prices result from Imhofs streamlined methods and full tooling for large-scale production in Europe's most modern factory fully equipped for quality manufacture of cases, racks and consoles

IMHOFS


Fully Radiused Sloping Panel Cases
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1410B 7" ×12" Panel Size £2 18 6
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These new cases have been designed as a result of the fast development in miniaturisation of electronics and electrical instruments. The cases are of two types: with sloping front panels, and rectangular cases with vertical front panels. Both types are available in standard duo-tone finishes. Imhofs have also produced a new type chassis incorporating fixing brackets especially for these new cases

7 days delivery–generous quantity discounts!

STOP PRESS! Now available, 9 new ultra-miniature cases—MINIBOXES—of two-piece construction. Sizes from 3"×1⅛"×2¼" to 17"×4"×5". Prices from 6/9 to 25/-. Complete details on request

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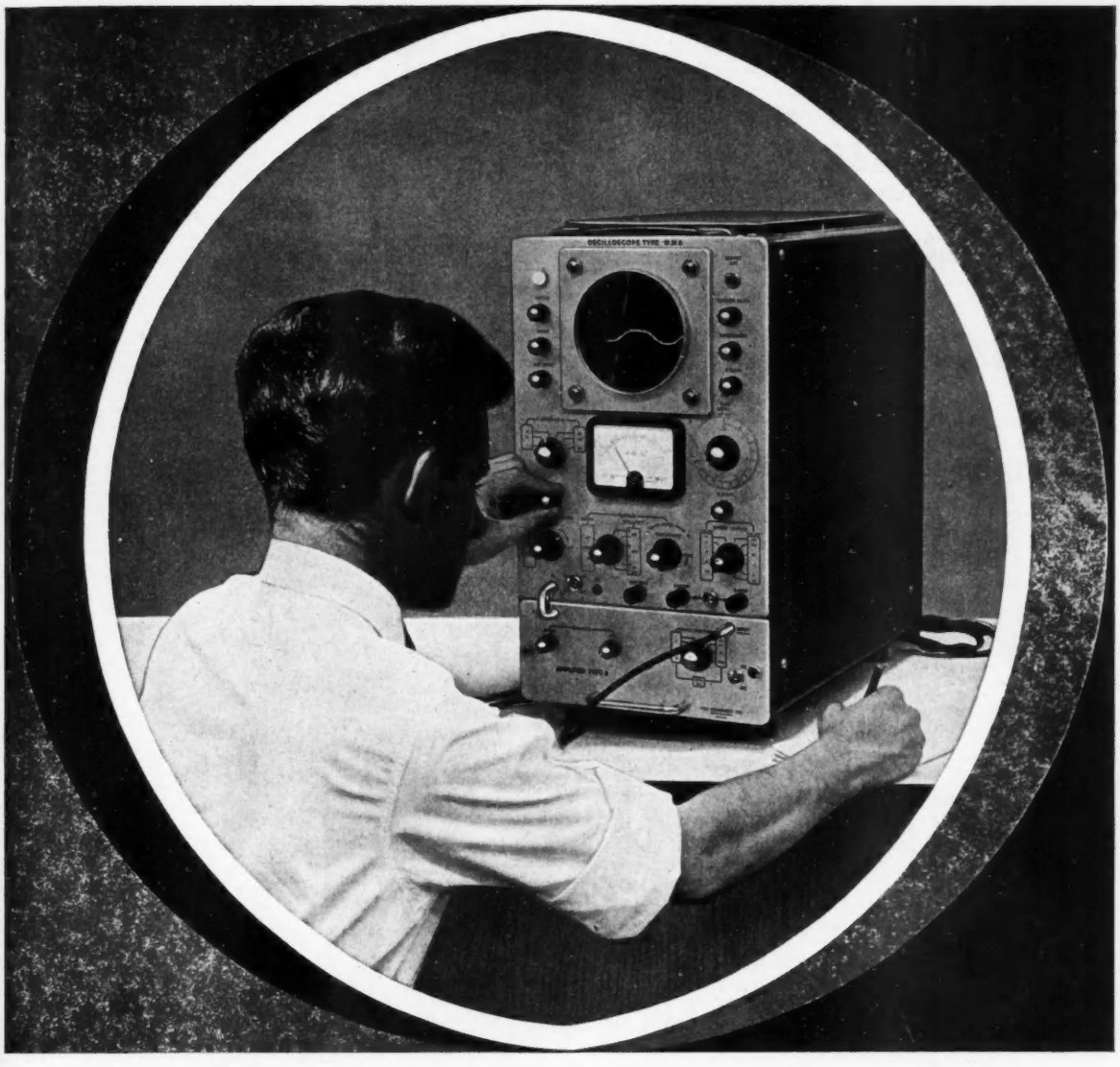

WM8 OSCILLOSCOPE A FIRST CLASS ALL-ROUNDER

THE WM8 OSCILLOSCOPE sets a new level of all-round performance for the general-purpose instrument. Far less expensive than any other oscilloscope of its class, it has been designed with special attention to compactness and ease of operation. Wide bandwidth, high sensitivity, fine accuracy and a variety of facilities make the WM8 particularly suitable for T.V. waveform analysis, pulse measurement, computer development, study of transients, and production testing.
Ask us for a demonstration, or for a leaflet with full technical details.

MAIN CHARACTERISTICS OF THE E.M.I. OSCILLOSCOPE TYPE WM8	
BANDWIDTH	*DC-15 Mc/s*
SENSITIVITY	*50mV/cm-25V/cm*
TIME BASE SWEEP SPEED	*50mμs/cm-15ms/cm*
MEASURING ACCURACY	*± 3%*
SIGNAL DELAY	*0.25 μs*
ANCILLARIES	*Various attenuator probes, pre-amplifier type 8, viewing mask, 75Ω termination pad, cameras etc.*

EMI

E.M.I. ELECTRONICS LTD

INSTRUMENT DIVISION
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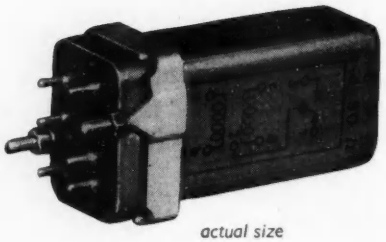
EE 15 066 *for further details*

For Switching MILLIVOLTS & MICROAMPS

SIEMENS EDISWAN

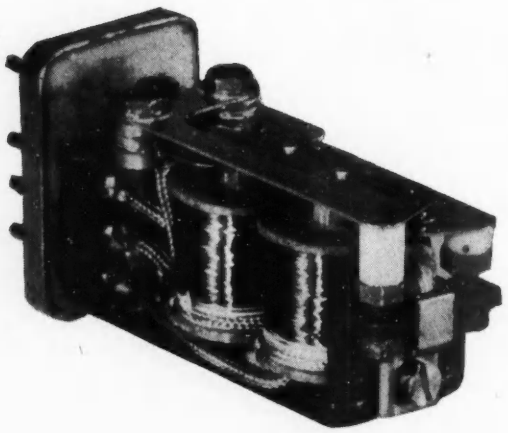


actual size

LOW CURRENT Switching Relay

This relay is a development of the well-known Siemens Ediswan miniature sealed high speed relay. In its construction, organic materials have been eliminated as far as possible, and a capsule, containing pellets of activated carbon, has been included to act as a "getter", adsorbing volatile materials that would otherwise contaminate the contacts.

The relay has a long life even under conditions of very frequent operation, and is therefore suitable for use as a "chopper" for converting low-power D.C. signals into alternating voltages. Under test, at the rate of 100 operations per second, and switching 25 millivolts at 1 microamp, a life of 10,000 hours is frequently obtained, corresponding to 3,600 million operations.



Full details may be obtained from

SIEMENS EDISON SWAN LTD
An A.E.I. Company
Telecommunications Division PD7
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PD7/9

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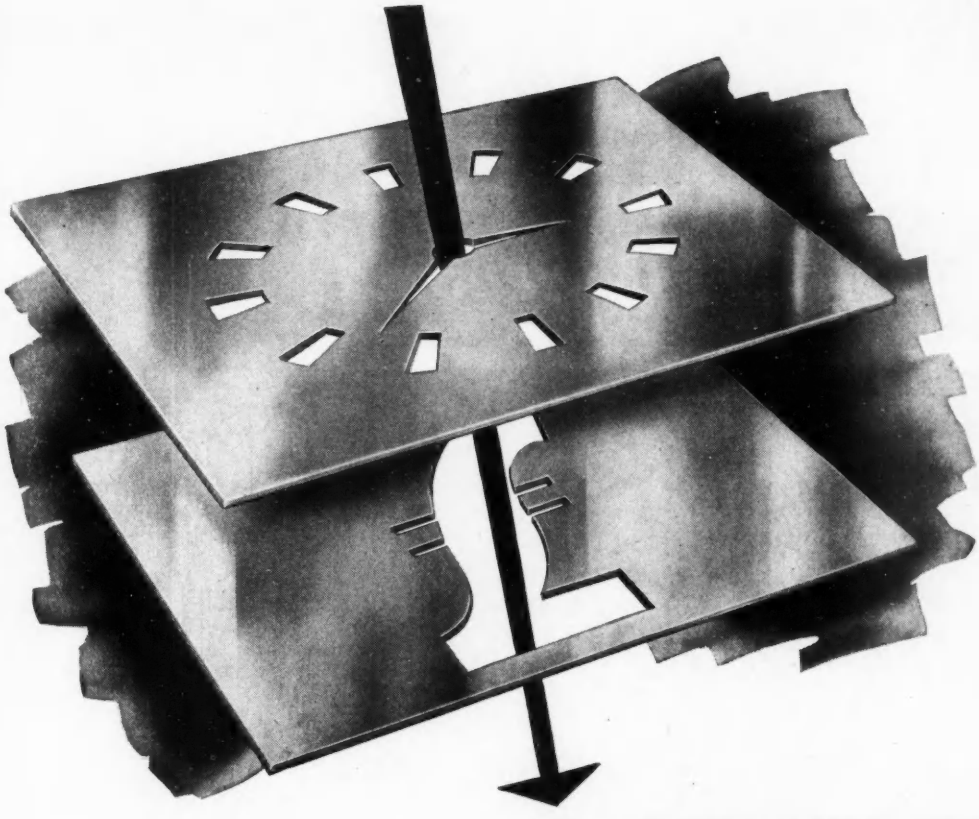

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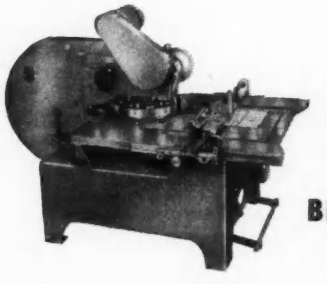
pierces the Time and Cost Barrier....

Wiedemann cuts the cost of short and medium run piercing by as much as 85% and does the job much better and much faster. No more marking out—No more setting up, drilling, flycutting, chiselling out or finishing to size and *no more costly tooling.* Modifications or complete changes of layout made quickly, easily, cheaply.

Write for Wiedemann Brochure No. EE/176 and study the 'hole' time and cost question—and send sketches of some of your jobs and ask for time studies.



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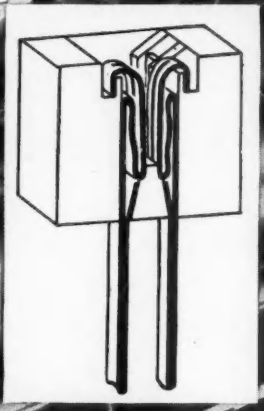
176

Continental Connectors



UNIQUE BELLOWS CONTACTS

for printed circuit connectors

Continental Connector Division
ULTRA ELECTRIC LIMITED
Western Avenue · Acton · London · W.3
Phone ACOrn 4404 Cables Radwaves London

Note: *Our artist's impression of the Mendlesham mast shows it flying the Union Jack. This in fact was only flown during 'Topping Out' — an informal ceremony held by erectors on completion of large-scale construction jobs.*

ONE THOUSAND FEET UP

AT MENDLESHAM!

On the 27th October High Power Transmission from the Mendlesham mast commenced. Over one million televiewers will now be able to receive a first-class service from the I.T.A. Station.

A thousand feet high, this mast is the tallest structure in Great Britain, yet it is only 8′ 6″ across each side of its triangular framework.

It was built in *ten weeks* to the requirements of I.T.A. and their main contractors, E.M.I. Electronics Ltd. The design and erection were undertaken by BIC Construction Company and the steelwork was fabricated and galvanised by Painter Bros. of Hereford — both members of the BICC Group.

Other transmitting masts and towers supplied by BICC include those at :—

CRYSTAL PALACE (London)
CHILLERTON DOWN (Isle of Wight)
SUTTON COLDFIELD (Birmingham)
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HOLME MOSS (Huddersfield)
BLACK MOUNTAIN (Belfast)
KIRK O' SHOTTS (Lanarkshire)
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BICC GROUP

BRITISH INSULATED CALLENDER'S CABLES LIMITED
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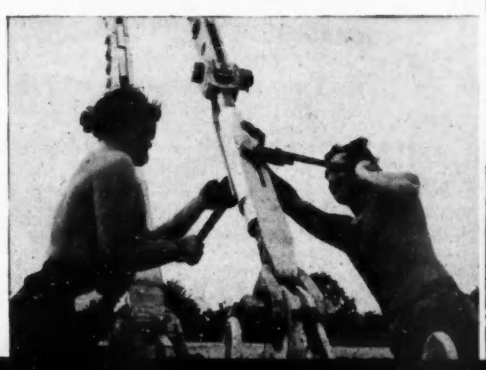

Tightening one of the steel wire supporting stays

Base of 1,000 ft. transmission mast

1959

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FIRST with the NEW

BULK PAK FOR WINDING WIRE

CONYPAK

A few of the advantages of winding wire supplied in Conypaks are as follows:-

Continuous long production runs.

Output increased due to reduced "down time" of the winding machines.

None of the troubles sometimes experienced with badly wound reels.

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Appreciable financial saving.

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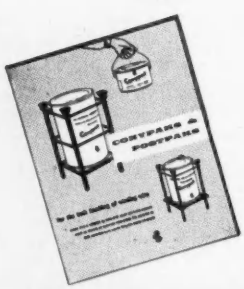
For ease of handling and storage the larger sizes of Conypaks can be supplied in steel stacking stillages or "Postpaks."



Wire sizes as fine as 36 s.w.g. can be supplied in Conypak packaging. The 50 lb. and 25 lb. Conypaks may be stacked and handled with ease. Please write for full details available in our Booklet Ref. C108-C.

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- **Low slope resistance**
  typical value less than 2 ohms
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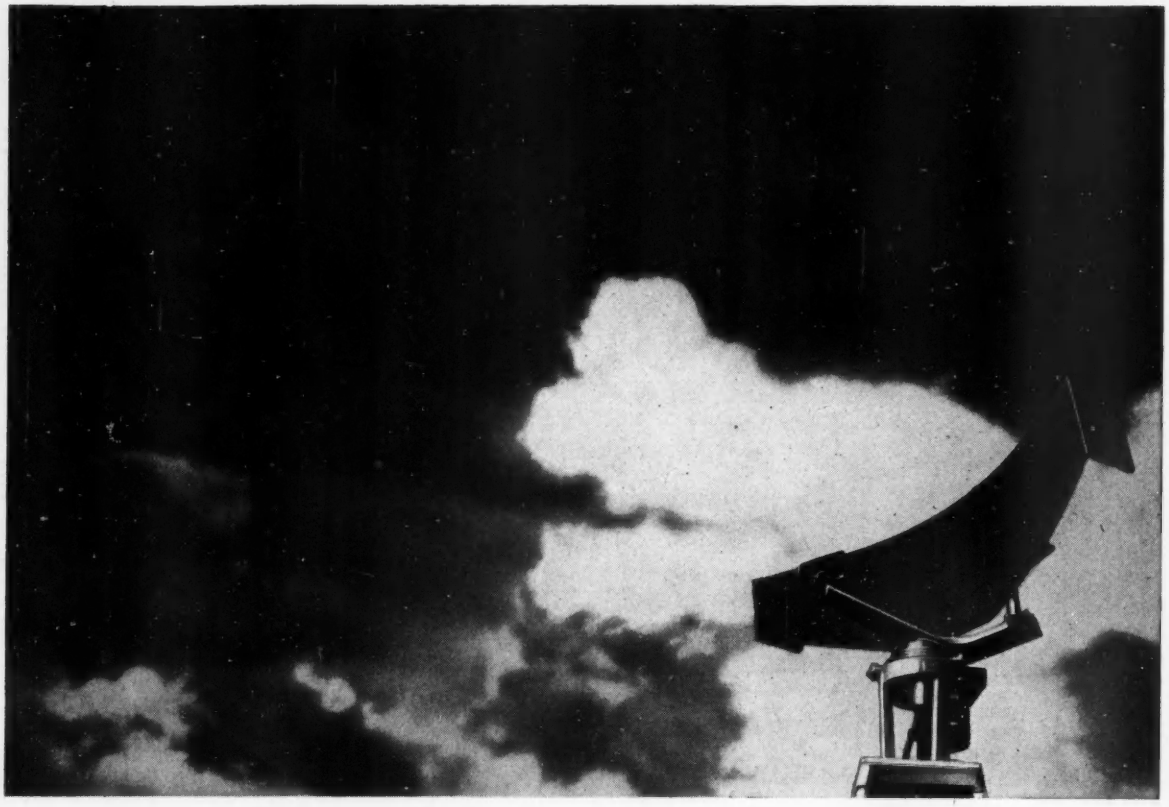
  to within ± 3 ohms of typical
- **Close tolerance Temperature Coefficient Curves**
- **Comprehensive Voltage Range**
- **Excellent High Temperature Performance**
  upper limit in excess of 200°C
- **High Stability**
- **Fully Tropical Construction**

TYPE	VR35-B	VR425-B	VR475-B	VR525A-B	VR525B-B	VR575A-B
Voltage Range	2·9–4·1	3·9–4·6	4·4–5·1	4·9–5·6	4·9–5·6	5·4–6·1
Slope Resistance at 25°C Max. Limit	20 ohms	19 ohms	18 ohms	17 ohms	12 ohms	10 ohms
Slope Resistance at 25°C Min. Limit	15 ohms	14 ohms	12 ohms	12 ohms	6 ohms	5 ohms
TYPE	VR575B-B	VR625-B	VR7-B	VR8-B	VR9-B	VR10-B
Voltage Range	5·4–6·1	5·9–6·6	6·4–7·6	7·4–8·6	8·4–9·6	9·4–10·6
Slope Resistance at 25°C Max. Limit	5 ohms	4 ohms	4 ohms	4 ohms	4 ohms	5 ohms
Slope Resistance at 25°C Min. Limit	0	0	0	0	0	0

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

ELECTRONIC APPARATUS DIVISION LINCOLN, ENGLAND

A5449



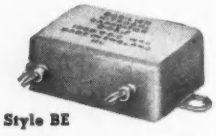
The eye that never blinks

Style BD

Style BC

Both the above Styles have high quality solder sealed ceramic terminals, and meet British Joint Specification RCS 131, temperature category –40°C to +100°C and humidity classification H1. Available for d.c. working up to 10kV. Capacitance range:— 0.05 to 8.0μF.

Style AE



Style BE

Style AE has Silicone rubber and moulded bushings and is recommended for general industrial and electronic applications requiring a working temperature range of –40°C to +70°C and a maximum of 1kV d.c. Wkg. Style BE has similar terminals to Styles BC and BD above, and meets the same requirements.

For complete information on these and many other Dubilier "Nitrogol" Capacitors, please write for illustrated Catalogues P.N.1 and P.N.2.

From the eternal vigilance of a radar warning system to the watchful precision of an automation plant one vital factor prevails — dependability. In systems such as these and in many other equipments Dubilier Nitrogol* Capacitors ensure unfaltering reliability. They are designed to work indefinitely in extremes of temperature and humidity and meet the most stringent British and American Government specifications.

* Nitrogol — a registered Dubilier trademark.

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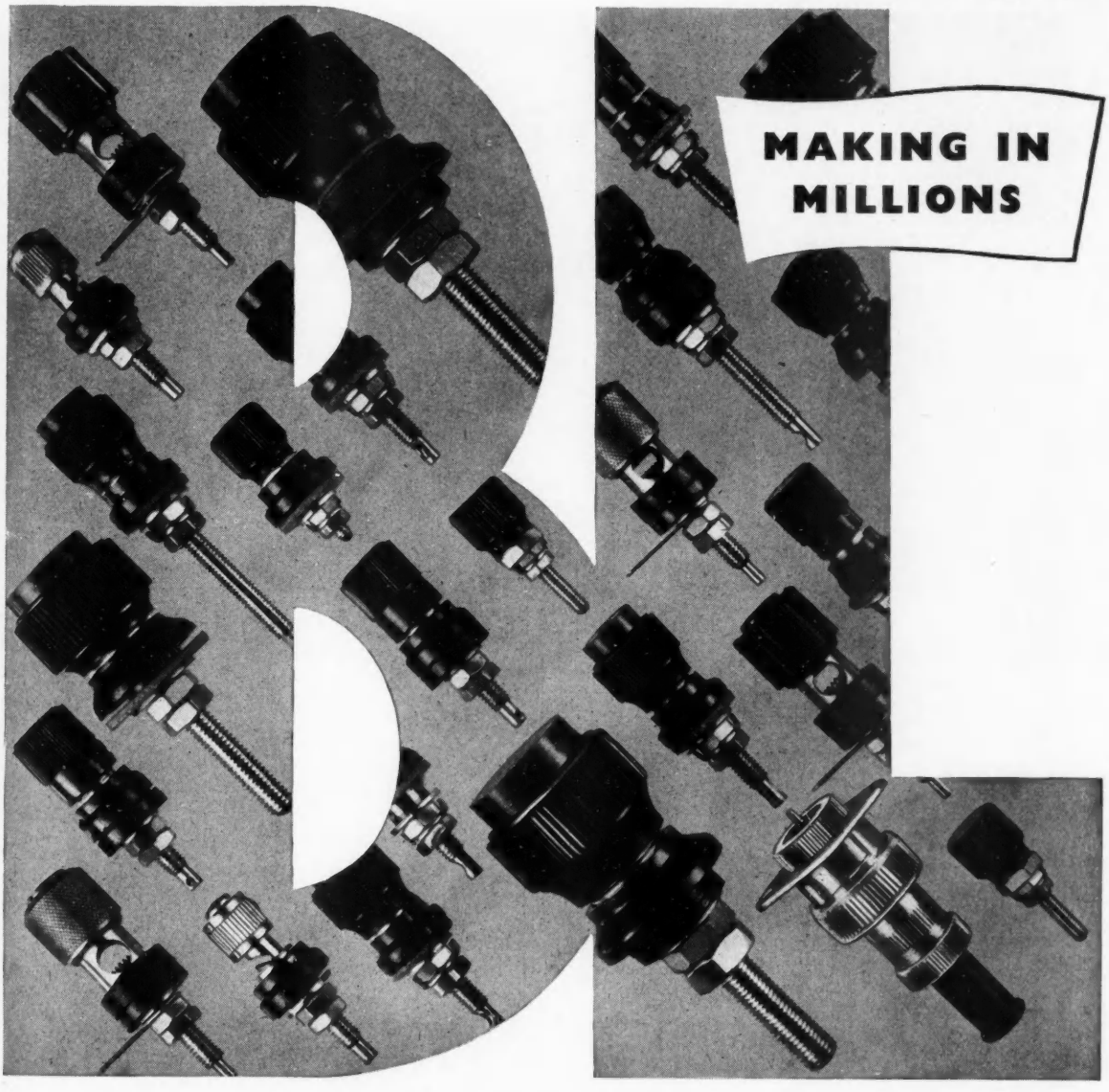
Cables: Hivoltcon, London. Telegrams: Hivoltcon, London, Telex. Telex: 25373

DN 224



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We make millions of terminals in a most comprehensive range of types and sizes. In many cases, collar assemblies are interchangeable, thus making possible a wide variety of combinations. Where our range—extensive as it is—does not provide for your particular requirements, we are always prepared to 'make to measure'.

We are specialists in components. This is no empty phrase: it means that we have been engaged in the design and manufacture of precision-made components for some thirty-five years, and at Enfield we devote a very great deal of our time and space to research, forever seeking new and better methods of production, whilst ensuring that every component maintains our high standard of performance.

Most "Belling-Lee" products are covered by patents or registered designs or applications.

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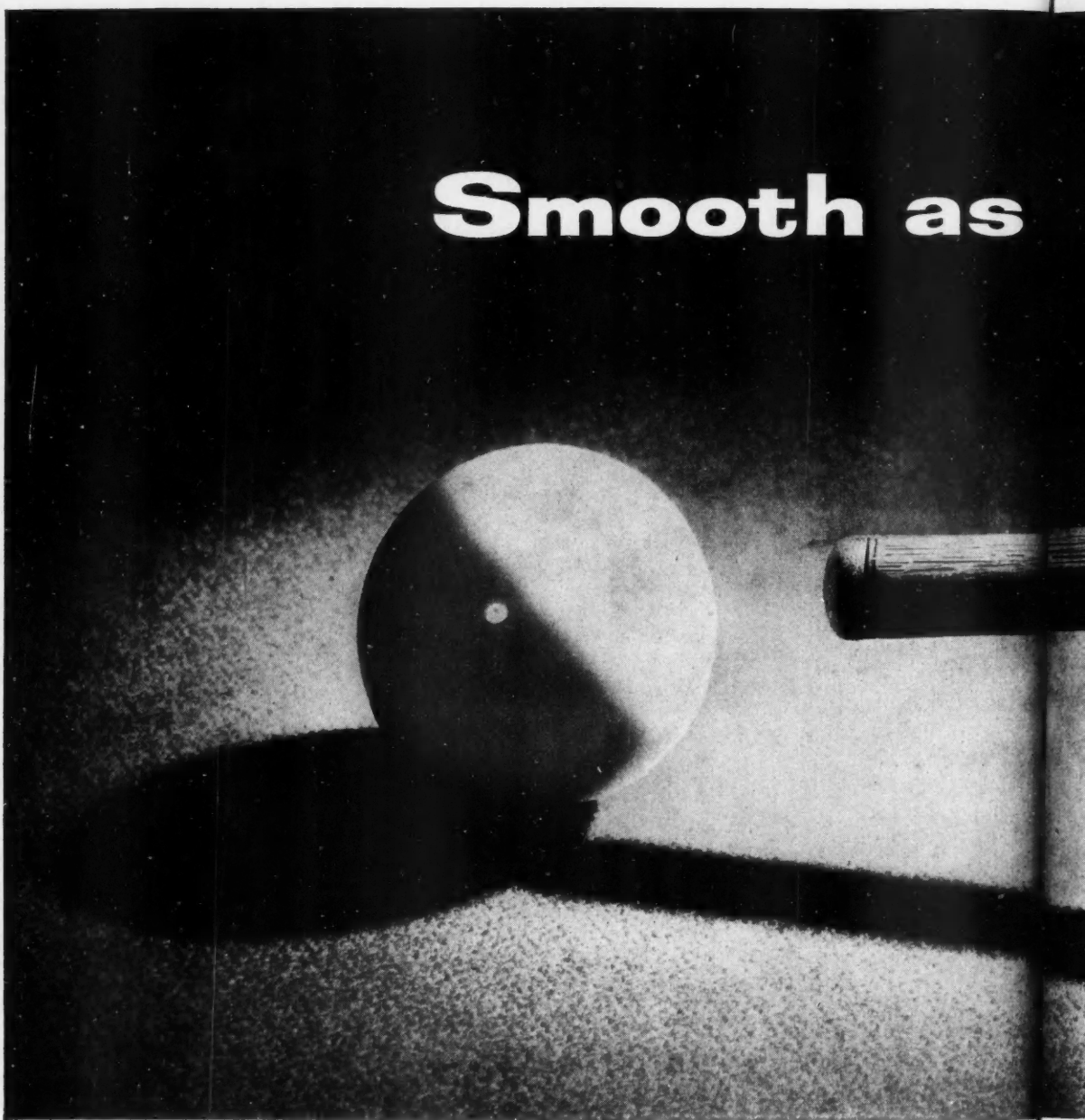
FUSES · INTERFERENCE FILTERS · RECEIVING AERIALS



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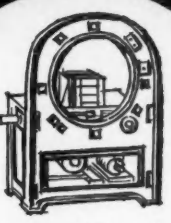
WARNER **Electric Brakes and Clutches**

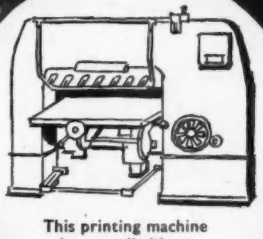
Acceleration and deceleration present no problems when machines are controlled by Warner units. They give instantaneous response—without shock. Control is positive and cushioned; not only for starting and stopping, but for positioning, tensioning, coupling, indexing and rapid cycling. Possibilities in machine construction are immense; production potentials have new peaks—through the greater flexibility of design offered by Warner *Electric* Brakes and Clutches. Send now for full technical details.

TAKE THE LEAD

ns a snooker stroke!



General assembly view of a wire tying machine controlled by a Warner 500 Clutch Brake.



This printing machine is controlled by a Warner 1000

Warner Electric Brakes and Clutches are manufactured in Great Britain under licence by:

WESTOOL LIMITED

ST. HELEN'S AUCKLAND, CO. DURHAM
Telephone: West Auckland 551/5
Telegrams: Solenoid, West Auckland

London: 2 Ashley Place, London, S.W.1. Telephone: Victoria 7301-2
Birmingham: 7 Newhall Street, Birmingham 3. Telephone: Central 3901

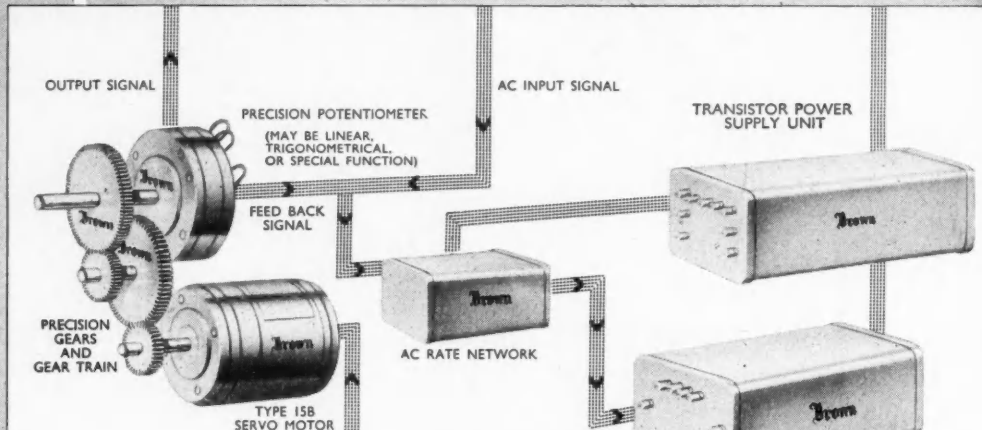
Westool also make: A.C. and D.C. Solenoids, Coils and Coil Winding Machines Transformers, Small Motors, Control Gears, Air Conditioners, etc.

TIB/126

LET WARNER ELECTRIC BRAKES AND CLUTCHES TAKE CONTROL

Brown

SERVO COMPONENTS



The range of servo components manufactured by S. G. Brown Ltd. include the following:—

1. Precision Potentiometers of 0.1% linearity.
2. AC Rate Networks (for stabilisation) size 2″ x 1½″ x 1″.
3. Transistor Power Supply Units. Size 4½″ x 1½″ x 2″.
4. AC Transistorised Servo Amplifiers. Gain 72 db. Power output 6.5 watts. Size 3¼″ x 1¼″ x 2″.
5. Type 15A and 15B Servo Motors.
6. Precision Gears and Gear Trains (cut to order).

Note: Operating temperature range for items 2, 3 and 4: —55° C to + 90° C.

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The Precision People

For further details please communicate with:—

S. G. BROWN LTD.

SHAKESPEARE STREET, WATFORD, HERTFORDSHIRE, ENGLAND

Telephone: Watford 27241 **Telegraphic Address: Sidbrownix, Watford**

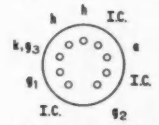
VALVES FOR A.C./D.C. BROADCAST RECEIVERS

EDISWAN MAZDA 10P18

The 10P18 is a miniature based Output Pentode having a maximum anode dissipation of 12 watts. It is intended for use as the audio output stage in a.c./d.c. mains powered equipment which uses series connected heaters.

Heater Current (amps)	I_h	0.1
Heater Voltage (volts)	V_h	45

BASE: NOVAL B9A



VIEW OF FREE END

MAXIMUM DESIGN CENTRE RATINGS

Anode Voltage (volts)	$V_{a(max)}$	250
Screen Voltage (volts)	$V_{g2(max)}$	200
Anode Dissipation (watts)	$p_{a(max)}$	12
Screen Dissipation (continuous) (watts)	$p_{g2(max)}$	1.75†
Mean Cathode Current (mA)	$I_{k(mean)max}$	100
D.C. Heater to Cathode Voltage (volts)	$V_{h-k(max)}$	200

†On speech and music the permissible rating at maximum signal voltage is 6 watts.

CHARACTERISTICS

Taken at $V_a = V_{g2} = 170V$, $V_{g1} = -12.5$ V, $I_a = 70$ mA.

Mutual Conductance (mA/V)	g_m	10
Anode Resistance $\left(\frac{\delta v_a}{\delta i_a}\right)$ (kΩ)	r_a	23
Inner Amplification Factor	μ_{g1-g2}	8

TYPICAL OPERATION Single Valve Class A Audio Amplifier

Anode Voltage (volts)	V_a	160
Screen Voltage (volts)	V_{g2}	170
Anode Current (quiescent) (mA)	$I_{a(o)}$	70
Screen Current (quiescent) (mA)	$I_{g2(o)}$	5
Grid Bias (volts)	V_{g1}	−12.5
Power Output for 10% Total Harmonic Distortion (watts)	P_{out}	5.2
Anode Load (ohms)	R_a	2,200
Input Swing for 10% Total Harmonic Distortion (r.m.s. volts)	$V_{in(r.m.s.)}$	7

These operating conditions are taken with fixed d.c. potentials.

INTER-ELECTRODE CAPACITANCES (pF)

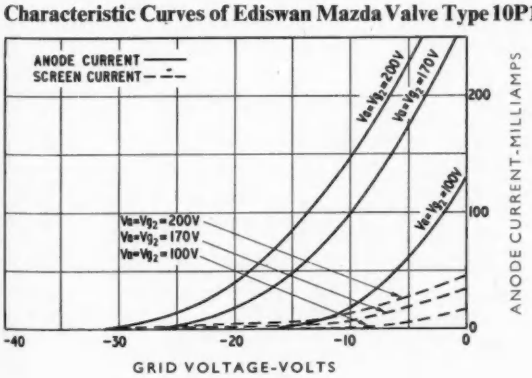
		*	†	‡
Grid 1 to Earth	C_{in}	12.4	12.9	14.6
Anode to Earth	C_{out}	6.5	7.7	8.8
Anode to Grid 1	C_{a-g1}	0.45	0.50	0.50
Grid 1 to Heater	C_{g1-h}	0.09	0.12	0.14

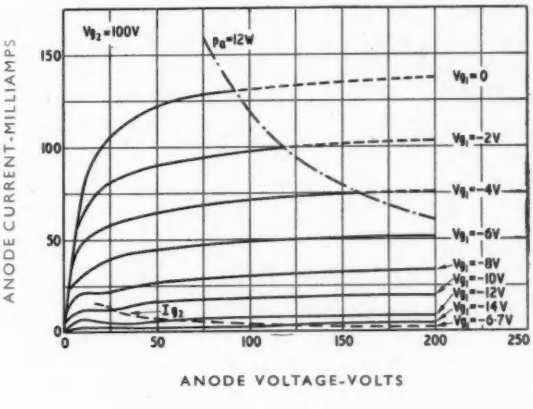
*Inter-electrode capacity in fully shielded jig, without can.
†Inter-electrode capacity with holder balanced out. (Using holder quoted below.)
‡Total inter-electrode capacity including B9A nylon phenolic holder without skirt or radial shield (Siemens Ediswan Clix Holder Type VH19/902).

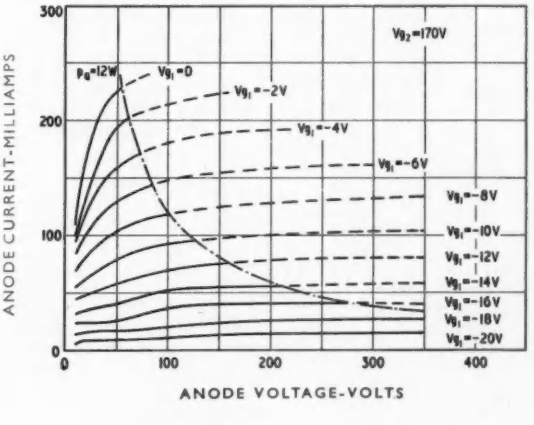
DIMENSIONS

Maximum Overall Length (mm)	78.5
Maximum Diameter (mm)	22.2
Maximum Seated Height (mm)	71.5

Characteristic Curves of Ediswan Mazda Valve Type 10P18







SIEMENS EDISON SWAN LIMITED *An A.E.I. Company*
Technical Service Department, 155 Charing Cross Rd., London, W.C.2
Telephone: GERrard 8660. Telegrams: Sieswan, Westcent, London.

EDISWAN
MAZDA

CRC 15/48

EE 15 078 *for further details*

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P Type
• Lumps: grade 150
400
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• Rods
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Silicon manufactured by PECHINEY is of the highest purity, being produced in the pure air of the high mountain Alps.
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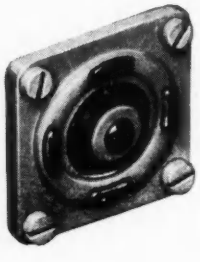

quietly doing a job

The photograph above shows a gramophone turntable bank in the Sound Control Room at the B.B.C. Television Studios, Lime Grove.

The arm and pick-up of the GLU9 groove locating units are mounted on pairs of SILENTBLOC Square Flange Instrument Type Anti-vibration Mountings, whose purpose is to make quite sure that no ground vibration interferes with the sensitive instruments and spoils absolute perfection of reproduction.

The B.B.C. are one of the many "perfectionist" customers who choose SILENTBLOC Instrument Mountings to do an exacting job.

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Come to us at the drawing board stage!

SILENTBLOC LIMITED MANOR ROYAL CRAWLEY SUSSEX
Telephone: Crawley 2100
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NOISE MEASURING EQUIPMENT TYPE 123

For operation at frequencies in the range 5—11 Kmc/s for the analysis of spurious a.m. and f.m. Fine resolution permits accurate measurements at signal to noise ratios of 135 dbs for modulation frequencies in the range 500 c/s to 95 Kc/s.

For further information write to:

JAMES SCOTT & CO. (Electrical Engineers) LTD

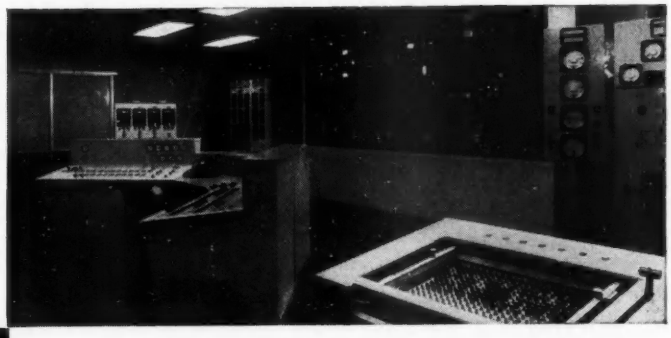
Manufacturing and Electronics Division

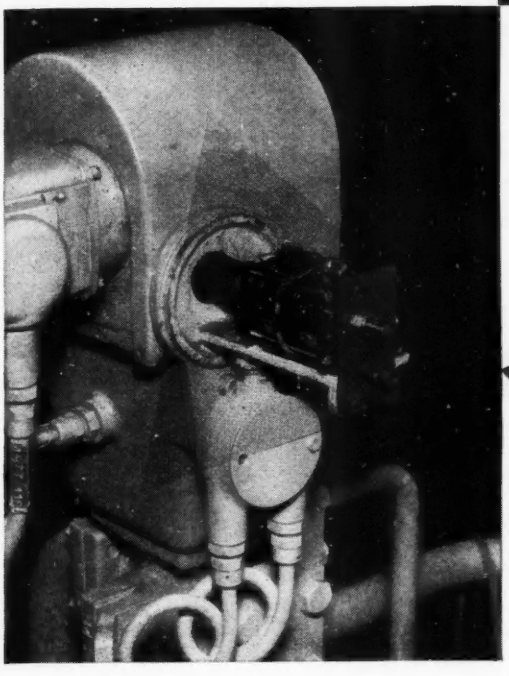
68 BROCKVILLE STREET, CARNTYNE INDUSTRIAL ESTATE, GLASGOW, E.2

Telephone SHETTLESTON 4206-9

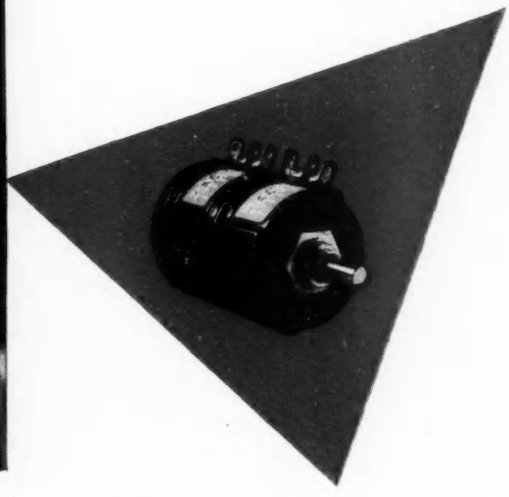
EE 15 081 *for further details*

ROLLS-ROYCE *chose* Helipot®





The Rolls-Royce Altitude Test Plant at Derby uses Beckman/Helipot Potentiometers exclusively
for valve position control and generation of control signals.



Above: Series 'C' Helipot, two gang unit, mounted on a large control valve at the Rolls-Royce Altitude Test Plant, Derby. These potentiometers ensure an accurate and fine control of temperature and pressure in the engine test cells, corresponding to the desired altitude conditions.

Helipots provide reliable, long-life operation, embodying 15 years' continuous improvement in design and manufacture.

Beckman/Helipot precision wire-wound helical potentiometers offer : superior resolution . . . superior linearity—continuous test on production . . . low noise — all pots tested to close specification . . . wide ambient temperature range . . . long life — minimum life expectancy specified . . . and can be supplied with multiple taps welded to individual wire turns, without reducing resolution.

We shall be pleased to discuss *your* applications and advise suitable types. All British-made Helipots can be supplied at competitive prices from stock, in a wide range of resistance values.

Special requirements can be met to order.

Write for data sheets to Dept. EE1

Beckman® / *Instruments Limited*

Glenrothes. Fife. Scotland
Tel: Glenrothes 551 Telex: 72135

Sales and Service, England and Wales :-
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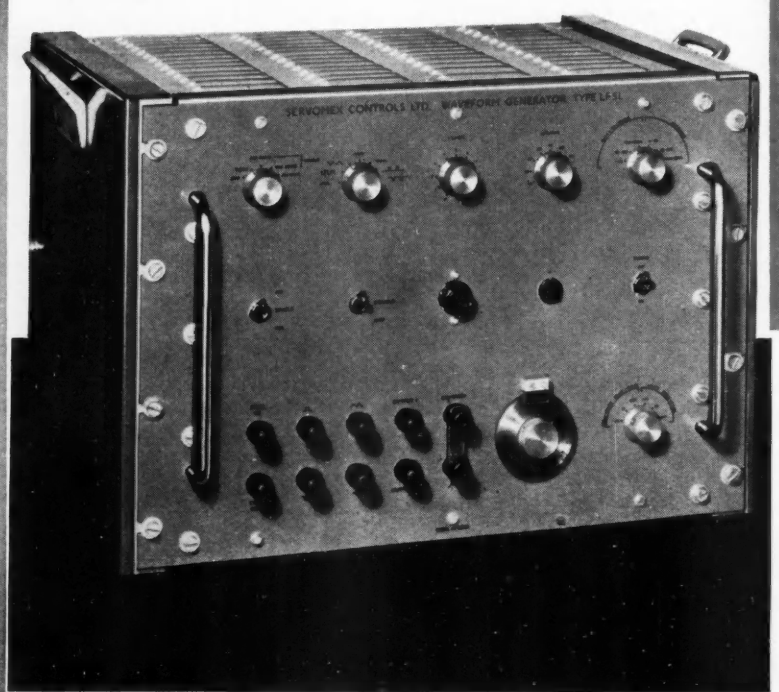
8393

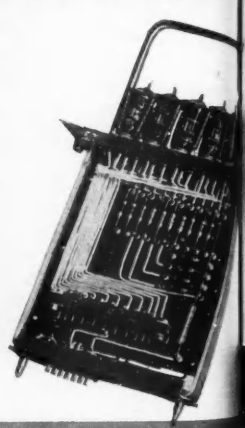
the most flexible supply of test signals for testing servo mechanisms

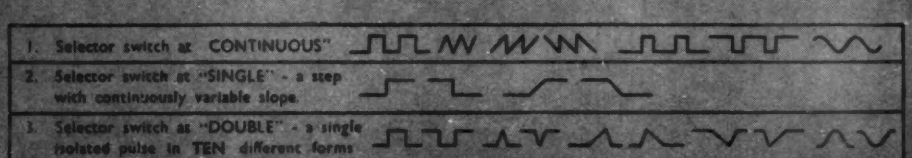
This unique instrument is being used by discriminating control engineers all over the world for measuring the dynamic response of automatic control systems.

With it, one can carry out measurements of the frequency response to sinusoidal input; the step-function response; the response to ramp functions; the response to sine-squared pulses; and many other special tests.

- ★ *Sine waves from 500 cycles/sec. down to one cycle every 2,000 secs. (33 minutes).*
- ★ *Pulses and square waves with rise time less than 10 microseconds.*
- ★ *Ramp functions with a linear rise variable from 1 millisecond to 1,000 seconds.*
- ★ *Over 30 different waveforms available.*
- ★ *Voltage variable between 100 microvolts and 150 volts peak-peak.*
- ★ *Load current up to 5 milliamps peak.*






1. Selector switch at "CONTINUOUS"
2. Selector switch at "SINGLE" - a step with continuously variable slope
3. Selector switch at "DOUBLE" - a single isolated pulse in TEN different forms

THE PROBLEM...

generate the Inverse Tangent Function $V = A \tan^{-1} Bt$ required for testing a particular control system

a possible solution,

spend several thousand pounds on an analogue computor and non-linear function units (as large and expensive as any white elephant, and less mobile)

the Servomex solution,

Fit a special plug-in unit to the standard LF. 51 (price £100, delivery 4 weeks). This is just another example of the unique flexibility of the LF. 51

The LF. 51 is a rugged, portable, £395, off-the-shelf instrument that gives 37 odd waveforms in the standard form including steps, ramps, sines, sine-squared pulses, and can so easily receive special units to generate the real *curiosa* erf x $\tan^{-1}x$ etc., etc.

These features are built-in by servo *specialists* who found that orthodox test gear was not up to the job. How *pleasing* that this all-British device is now accepted as orthodox among control engineers from San Francisco to Peking.

SERVOMEX

Servomex Controls Ltd Crowborough Sussex
Crowborough 1247

low frequency wave form generator

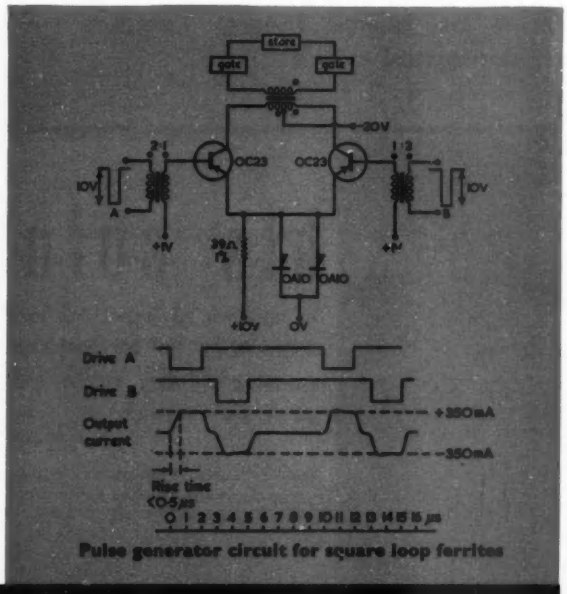
the World's best !

High frequency - High gain

OC23 Computing Transistor

The OC23 is designed and specially tested for driving square-loop ferrite computing elements and storage matrices. Its high f_α and power handling capabilities, however, suit it for a number of additional computing applications.

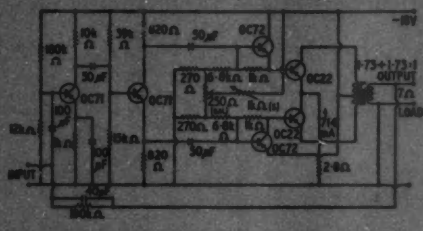
- Ferrite drive transistor providing 1-amp pulses with rise time <0.8 μsec.
- Half and full current pulse generator transistor for ferrite stores of up to 40,000 bits capacity.
- Gating transistor for use with ferrite stores.
- Clock pulse generator transistor for medium speed computers.



Pulse generator circuit for square loop ferrites

OC22 High quality industrial A.F. Transistor

The f_α of 2 Mc/s of the OC22 ensures that the negative feedback used in quality a.f. amplifiers does not cause h.f. oscillation. In addition, the α' gives a generous final gain even allowing for the inevitable reduction through negative feedback, thus reducing the power required from the drive stage. An extremely linear α'/I_c characteristic is yet another reason for using the OC22 in transistorised industrial a.f. equipment where quality is of paramount importance.



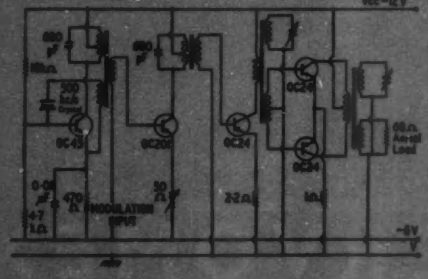
4-watt experimental a.f. amplifier circuit

Total harmonic distortion at 4W output (measured at 400 c/s)	<1.0%
Frequency response (400 c/s ref. level) ...	± 2 dB 20 c/s to 20 kc/s
Feedback factor (with 2.5 kΩ source)	20 dB
Sensitivity (input current for full output)	30 μA

OC24 Communications Transistor

The OC24 is particularly suited for communications applications. Two of these transistors are, for example, used in the output stage of a marine distress transmitter where they provide 4 watts c.w. at 500 kc/s. The OC24 can, of course, be used for modulated c.w. or telephony.

Another example of the application of the OC24 in the field of communications is a 12 channel telephone repeater amplifier which conforms to the full C.C.I.T. Specification. This amplifier has an output of 0.5 watt at 120 kc/s.



4-watt 500 kc/s Transmitter

EE 15 085 *for further details*

Power transistors

10 watts dissipation
2 Mc/s average f_α

High frequency cut-off, high α', high dissipation and low bottoming voltage are all combined in the Mullard OC23 — a leading transistor of its kind in the world.

The OC23 and its companion types OC22 and OC24 are now being made by Mullard in extremely large quantities and are immediately available at economic prices. Telephone or write Mullard House for full information and assistance in selecting the type most suited for your particular application.

Germanium P-N-P Alloy Junction Transistors
Characteristics (at $T_{junction}$ = 25°C) for OC22, OC23 and OC24.

GROUNDED BASE			
Collector Leakage Current		*Typical*	*Max.*
(at V_c = -10V, I_e = 0)	$I_{c(o)}$	30 μA	100μA
Emitter Leakage Current			
(at V_e = -10V, I_c = 0)	$I_{e(o)}$	20 μA	100μA
GROUNDED EMITTER			
Collector Bottoming Voltage			
(at I_c = 1.0A, I_b = 30mA)	V_{ce}	-400mV*	—
Current Amplification Factor		*Typical*	*Min.*
(at V_c = -2V, I_c = 100mA)	$\bar{\alpha}'$	200	—
(at V_c = -2V, I_c = 1.0A)	$\bar{\alpha}'$	150	50

* -400mV for OC23 and OC24 only. OC22 = -600mV.

MULLARD LIMITED
Semiconductor Division
Mullard House · Torrington Place
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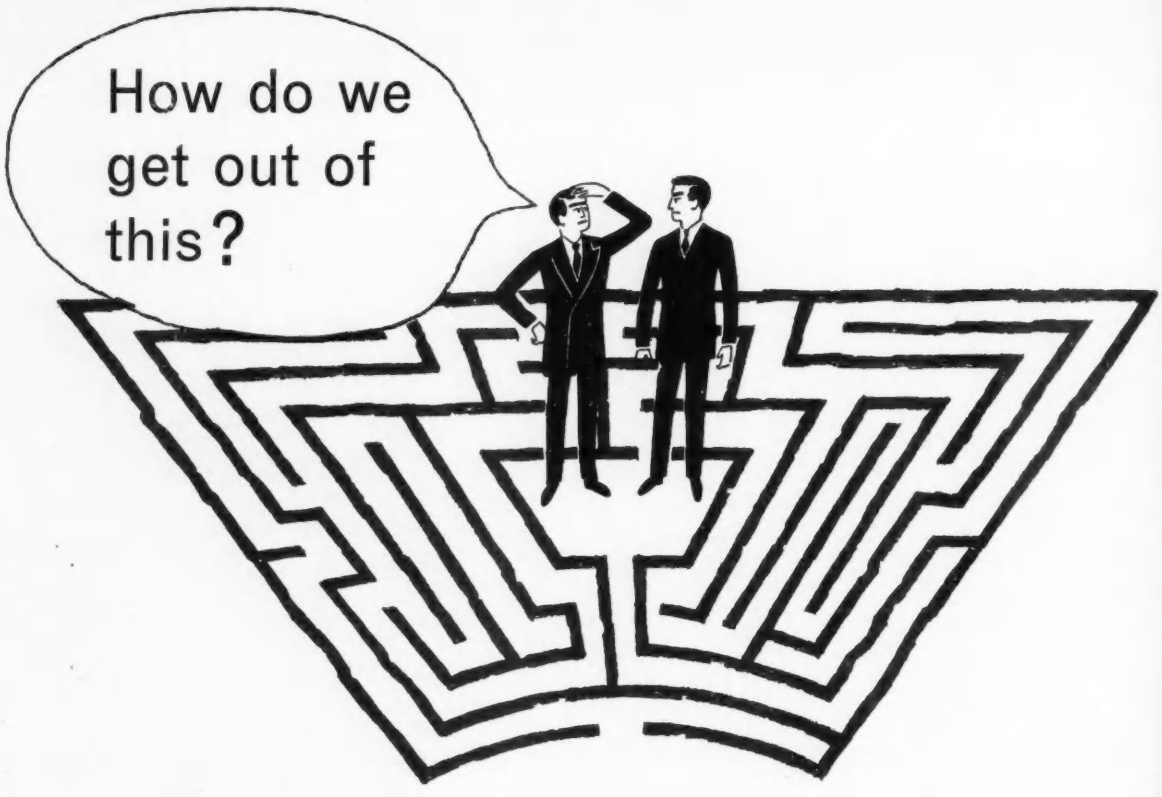
Mullard
semiconductor division

MI512



People go into Hampton Court maze for fun, because they want to—and because they know that someone will get them out if they get lost.
Mazes in industry are a different matter. The tangles that have to be straightened out in the development of a new product can be anything but fun, and a little expert help can be very welcome.

consult **Varley** REGD TRADE MARK

service to industry

We are specialists in design for mass-production and we also design and mass-produce to special requirements.
Here are some of the development problems we've tackled.
Relays and Coils for the Aircraft Industry
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Coils, Solenoids and Harnesses for the Automobile Industry
Motors and Solenoids for Washing Machines
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Telegrams: Olipel, London, S.E.18

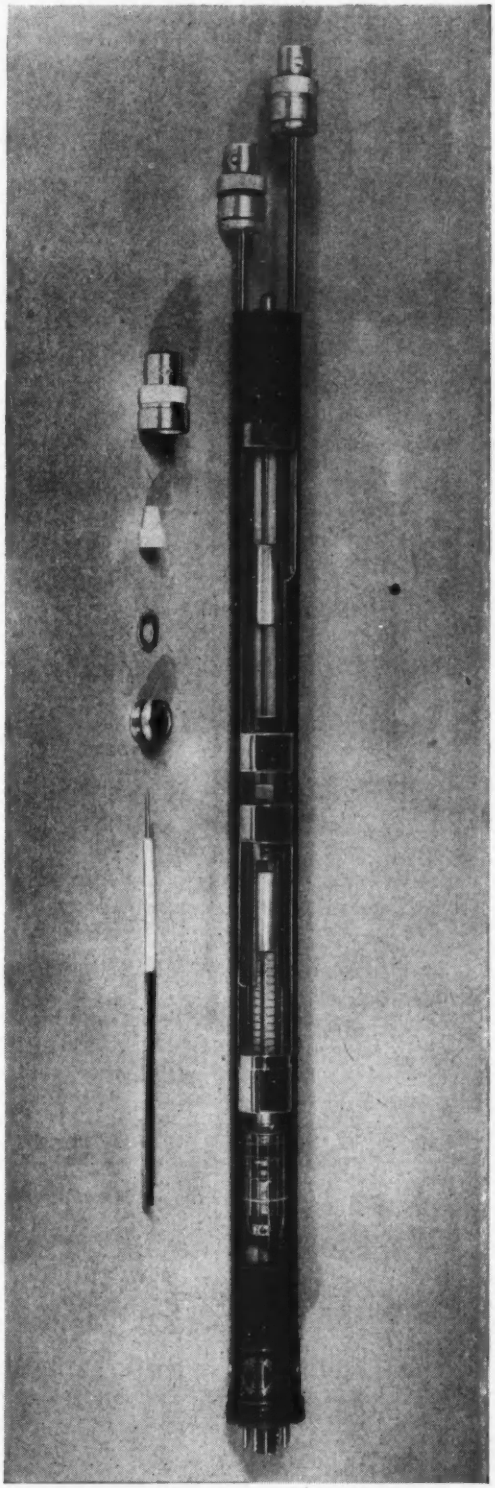
TA2554

EE 15 087 *for further details*

'FLUON' INCREASES PRODUCTION IN THE ELECTRICAL INDUSTRY

English Electric Valve Co. Ltd. use 'Fluon' components in travelling wave tube for radio link equipment

Because it is the best of the solid dielectrics, having a very low permittivity and power factor, and is an excellent electrical insulator, 'Fluon' p.t.f.e. is used for components in the travelling wave tube, made by English Electric Valve Co. Ltd., Chelmsford, for radio link equipment. One of the most important outlets of 'Fluon' is in the electrical and electronics industries. It is being used in a wide variety of ways ranging from cable and wire insulation to TV antennae insulators; from a high temperature condenser dielectric to low friction bearings for variable resistors. Apart from its excellent electrical properties, 'Fluon' has many other advantages. It has a remarkable working temperature range from +250°C. down to liquid nitrogen temperatures. It is tough yet flexible, and has good impact strength. It is chemically inert and has a non-stick surface which is self-lubricating.



'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

'Fluon' components in travelling wave tube made by English Electric Valve Co. Ltd., Chelmsford.

IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

PF.59

A RANGE OF TRANSISTORISED

with these features

★ **FOUR TERMINAL NETWORK**
nominally zero impedance at your circuit. Resistance of interconnecting leads automatically eliminated.

★ **OVERLOAD PROTECTION**
latching relay ensures unit cut out on overload. Fuses protect unit against component failure.

LOW TEMPERATURE RISE
exclusive use of C core transformers.

★ **METERS**
grade 1 E. TURNER ammeter and voltmeter.

WORKMANSHIP
to highest standards, **ROBAND** standards.

PERFORMANCE

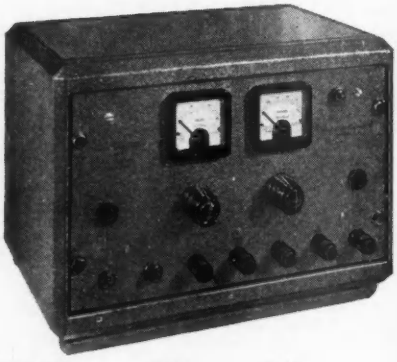
IMPEDANCE: <0.05 ohm
RIPPLE: <1 m.V
OUTPUT VARIATION: Less than 1 part in 1200 for 7% mains change.

MAINS 200/250V. A.C. (115V models available)

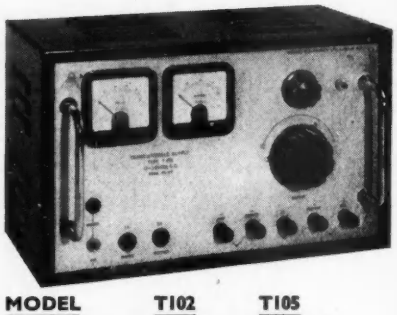
★ Not applicable to sub-units.

ALL PRICES EX-WORKS

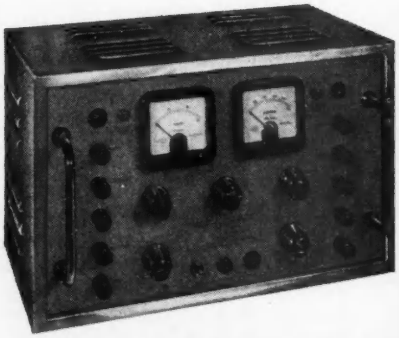
PLEASE NOTE OUR NEW ADDRESS AND TELEPHONE NUMBER



MODEL	T101	T103
Output:	0-50V, 1A	0-30V, 1A
Size:	13½" x 9" x 9½" high	
Weight:	17 lbs.	
Price:	£93	£85



MODEL	T102	T105
Output:	0-30V, 2A	0-50V, 2A
Size:	16½" x 8" x 10½" high	
Weight:	35½ lbs.	
Price:	£100	£118



MODEL T104 0-30/0-30V, each section 1A.

Size:	16½" x 8" x 10½" high
Weight:	35½ lbs.
Price:	£129

Basically a centre tapped D.C. supply with independent controls.

REGULATED SUPPLIES . . .

MODEL T100 25V max at 1A.

Size:	7½" x 4" x 5½" high
Weight:	5 lbs.
Price:	£45

MODEL T108 50V max at 1A.

Size:	8¼" x 5¼" x 6¼" high
Weight:	8 lbs.
Price:	£55

MODEL T109 50V max at 2A.

Size:	10¼" x 5¼" x 7½" high
Weight:	13 lbs.
Price:	£70

All sub-units are supplied at fixed voltages. Thus a T100/24 is a 24V 1A supply. The output can be readily altered to any fixed voltage within the range.

MODEL T106 0-100V, 1A.

Size:	21½" x 13" x 11½" high (Standard 19" x 8¾" panel)
Weight:	50 lbs.
Price:	£149

MODEL T107 0-100V, 2A.

Size:	21½" x 13" x 11½" high (Standard 19" x 8¾" panel)
Weight:	60 lbs.
Price:	£183

Also: A RANGE OF FIXED AND VARIABLE STABILISED SUPPLIES UP TO 500 V
And: A RANGE OF R.F. STABILISED SUPPLIES UP TO 50 K.V.

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A COMPLETE RANGE OF VACUUM TUBE REGULATED SUPPLIES

WITH THESE FEATURES . . . .

FREQUENCY RESPONSE—complete stability from 1 c.p.s. to beyond 100 k.c.s.

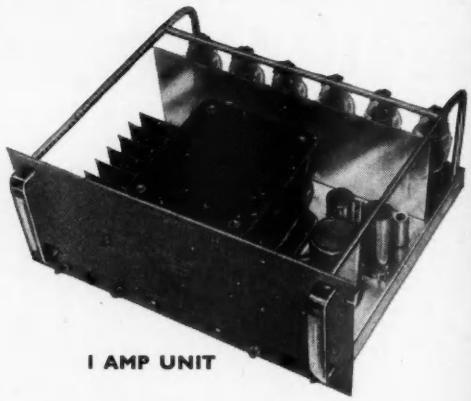
STABILITY—guaranteed for ± 10% mains variation—double triode difference amplifiers ensure freedom from drift.

LIFE—conservatively rated components ensure long life.

IMPEDANCE—a preset potentiometer allows for smooth impedance adjustment from positive to negative values

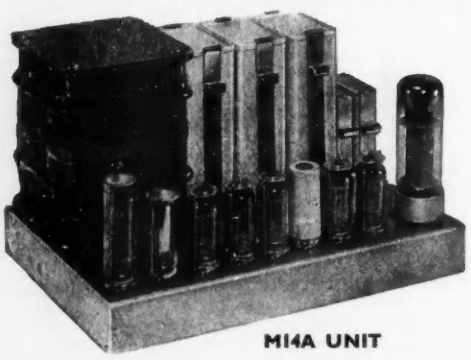
MAINS—200/250 V.A.C. (115V models available).

FRONT PANEL UNITS—fitted with Plessey Mark IV or Films & Equipment Jones type plugs & sockets. Please state preference.



1 AMP UNIT

Model	D.C. Output		A.C. Outputs	Effective Resistance	Voltage Stability	Ripple	Size	Price Ex-works
	Volts	Currents						
OPEN CHASSIS UNITS								
M23	±150V	0-50mA	6.3V2A & 6.3V1A	<0.1 Ω	<0.02%	<1mV	6″×5½″×5½″ ht.	£30-0-0
M23A	±200V	0-50mA	6.3V2A & 6.3V1A	<0.1 Ω	<0.02%	<1mV	6″×5½″×5½″ ht.	£30-0-0
M33	±250V	0-50mA	6.3V2A & 6.3V1A	<0.1 Ω	<0.02%	<1mV	6″×5½″×5½″ ht.	£27-10-0
M14A	±100V	0-100mA	2×6.3V3A C.T.	<1.0 Ω	<0.02%	<1mV	10⅜″×7″×6½″ ht.	£63-0-0
M24	±150V	0-100mA	2×6.3V3A C.T.	<0.1 Ω	<0.02%	<1mV	7⅜″×6¾″×6½″ ht.	£33-10-0
M24A	±200V	0-100mA	2×6.3V3A C.T.	<0.1 Ω	<0.02%	<1mV	7⅜″×6¾″×6½″ ht.	£33-10-0
M34	±250V	0-100mA	2×6.3V3A	<0.1 Ω	<0.02%	<1mV	7⅜″×6¾″×6½″ ht.	£33-10-0
M34A	±300V	0-100mA	2×6.3V3A	<0.1 Ω	<0.02%	<1mV	7⅜″×6¾″×6½″ ht.	£33-10-0
M25	±150V	0-200mA	2×6.3V3A C.T.	<0.1 Ω	<0.02%	<1mV	8¾″×8½″×6½″ ht.	£52-10-0
M25A	±200V	0-200mA	2×6.3V3A C.T.	<0.1 Ω	<0.02%	<1mV	8¾″×8½″×6½″ ht.	£52-10-0
M35	±250V	0-200mA	2×6.3V3A	<0.1 Ω	<0.02%	<1mV	8¾″×8½″×6½″ ht.	£52-10-0
M35A	±300V	0-200mA	2×6.3V3A	<0.1 Ω	<0.02%	<1mV	8¾″×8½″×6½″ ht.	£52-10-0
M26SA	±200V	0-500mA	2×6.3V5A C.T.	<0.1 Ω	<0.02%	<1mV	14″×11¼″×8″ ht.	£88-0-0
M36S	±250V	0-500mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	14″×11¼″×8″ ht.	£88-0-0
M36SA	±300V	0-500mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	14″×11¼″×8″ ht.	£88-0-0
M28A	±200V	0-350mA	2×6.3V5A C.T.	<0.1 Ω	<0.02%	<1mV	13½″×8¾″×6⅞″ ht.	£66-0-0
M38	±250V	0-350mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	13½″×8¾″×6⅞″ ht.	£66-0-0
M38A	±300V	0-350mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	13½″×8¾″×6⅞″ ht.	£66-0-0
19 in. FRONT PANEL UNITS								
M26A	±200V	0-500mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×12″×8¾″ ht.	£97-10-0
M36	±250V	0-500mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×12″×8¾″ ht.	£97-10-0
M36A	±300V	0-500mA	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×12″×8¾″ ht.	£97-10-0
M27A	±200V	0-1.0A	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×15¾″×8¾″ ht.	£165-0-0
M37	±250V	0-1.0A	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×15¾″×8¾″ ht.	£165-0-0
M37A	±300V	0-1.0A	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×15¾″×8¾″ ht.	£165-0-0
M29A	±200V	0-2.0A	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×18″×10½″ ht.	£255-0-0
M39	±250V	0-2.0A	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×18″×10½″ ht.	£255-0-0
M39A	±300V	0-2.0A	2×6.3V5A	<0.1 Ω	<0.02%	<1mV	19″×18″×10½″ ht.	£255-0-0



M14A UNIT

MADE AND GUARANTEED BY

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ELECTRONICS LIMITED

Beulah Works, Beulah Road, Thornton Heath, Surrey

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Price -works
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606/7/8

1959

Bextrene BC 15

was chosen as the ideal material for these intricate mouldings — the T.V. screen surround and mask in this R.G.D. Television set.

For surface Finish
a high finish which enhances the prestige look of the set.

For Impact Strength and Dimensional Stability
a frame that won't distort and which gives a high degree of protection for the delicate interior.

For good Mouldability
BC 15 is an excellent material for injection moulding and sheet extrusion. Because of its toughness, mouldings can be ejected without fracture from really intricate dies.

Screen surround and mask for television set moulded in two interlocking sections by Halex for R.G.D. (Radio Gramophone Development Co. Ltd.)

Bextrene BC 15 is available in a wide range of attractive colours.

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BX PLASTICS LTD *A subsidiary of The British Xylonite Co. Ltd.*

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a complete service in all sizes of

SLIP RING ASSEMBLIES

the revolutionary

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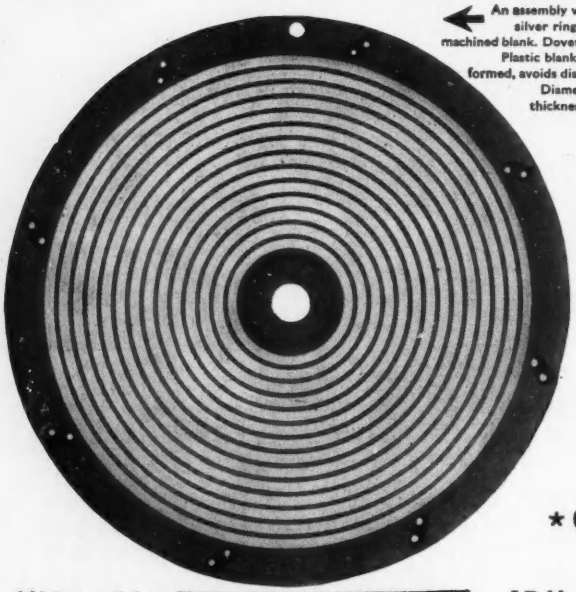
PROCESS *

for your LARGE SLIP RING ASSEMBLIES

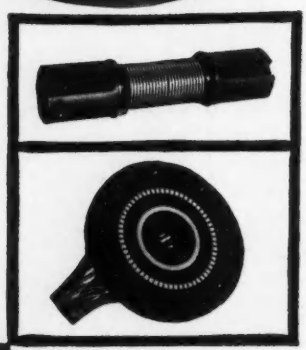


An assembly with 14 concentric hard silver rings electrodeposited into machined blank. Dovetail locks rings in place. Plastic blank cured before rings are formed, avoids distortion due to stresses. Diameter approximately 11", thickness approximately 5/16".

A multiple cylindrical assembly consisting of two 10 ring assemblies and four 1 ring high current power assemblies. Diameter approximately 11", length approximately 20". Photo courtesy of Marconi's Wireless Telegraph Company Limited.

Featuring

★ Lower cost ★ Closer tolerances
★ One piece construction ★ Uniform hardness
★ Reduced weight



A 24 ring assembly for thermocouple and strain gauge commissioning tests on large electrical machinery. Silver rings electrodeposited into plastic blank cast over a solid dumb-bell shaft. Diameter of slip ring 4.5". Overall length of rings 10". Photo courtesy of The English Electric Co. Ltd.

A 60 way high speed face commutator for industrial control application. Segments dovetailed into plastic. Diameter 3", thickness .25".

I.D.M. Electronics Limited is now tooled up with new expanded facilities for production of Large Slip Ring Assemblies to exact customers specification. Sizes range up to 36" diameter, either cylindrical or disc type.

The exclusive Electro Tec Process*—the electrodeposition of hard silver rings into an accurately machined plastic blank—consistently yields a high degree of dimensional accuracy, excellent concentricity, and a jewel like ring finish. One piece construction precludes dimensional variations due to accumulated errors. The plastic base is fully cured before rings are plated into it, thus preventing separation of base material from the rings. The silver rings are uniformly hard for long life—70-95 Brinell. This process also eliminates expensive tooling charges giving lower costs than possible with other methods of manufacture.

I.D.M. Electronics' Large Slip Ring Assemblies are widely used in Radar Equipment, Industrial Control Systems, Test Tables and many other critical applications. Light weight combined with rugged durability recommends their use in air-borne applications.

Every user knows I.D.M. Electronics' reputation for quality and superiority in miniature and sub-miniature slip ring assemblies.

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INSULATION RESISTANCE: greater than 20×10^{12} ohms (measured at 500V d.c.)

BREAKDOWN VOLTAGE BETWEEN CONTACTS: greater than 3.5 kV d.c.

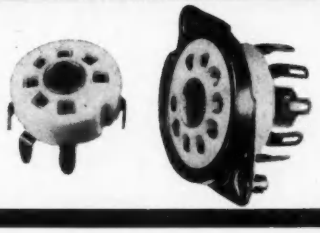
POWER FACTOR OF CERAMIC: better than 0.001

CONTACT RESISTANCE: less than 4 milli Ω

CAPACITANCE VALUE: less than 0.5pF pin to pin at 1 Mc/s.

For low moisture absorption, high insulating qualities and resistance to temperature, high stability ceramic valveholders are the obvious choice, and Plessey offer you a wide range at attractive prices. This is because they have successfully overcome certain manufacturing difficulties with ceramic materials and can now pass on to you the advantages of economic production. The exclusive design of the contact ensures constant pressure and low contact resistance throughout the working life.

Write now for samples and prices.

ceramic  valveholders

Plessey

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TC10

* ***Wire wound resistors*** *on porcelain formers that can be pre-set by adjustable tapping bands to precise values.*

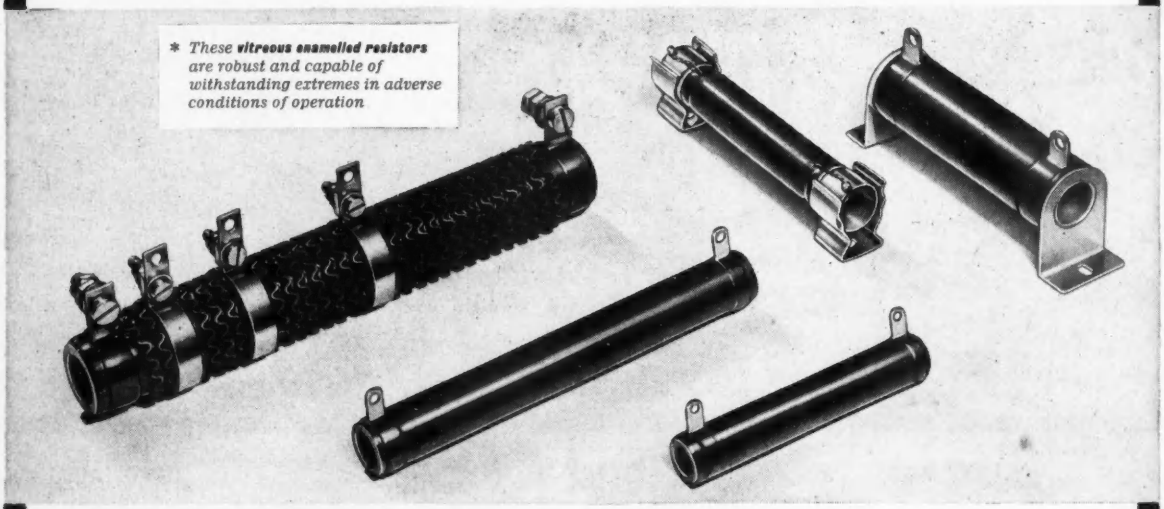
RESISTORS

...from the largest...to the smallest

The smallest resistor engineered by Expamet Cressall is approximately of 4 watts rating. Above this, almost any size and type of resistor or rheostat can be supplied. Such a service is unique and backed by unrivalled experience. Technical advice that makes full use of this unrivalled experience is freely available.

EXPAMET and CRESSALL–go together all the way

* *These* ***vitreous enamelled resistors*** *are robust and capable of withstanding extremes in adverse conditions of operation*



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The Electrical Division of
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Marconi in Telecommunications

The post and telegraph authorities of more than 80 countries use Marconi equipment

MARCONI **COMPLETE COMMUNICATION SYSTEMS**
SURVEYED · PLANNED · INSTALLED · MAINTAINED

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Manufacturers of precision-cast waveguide components for

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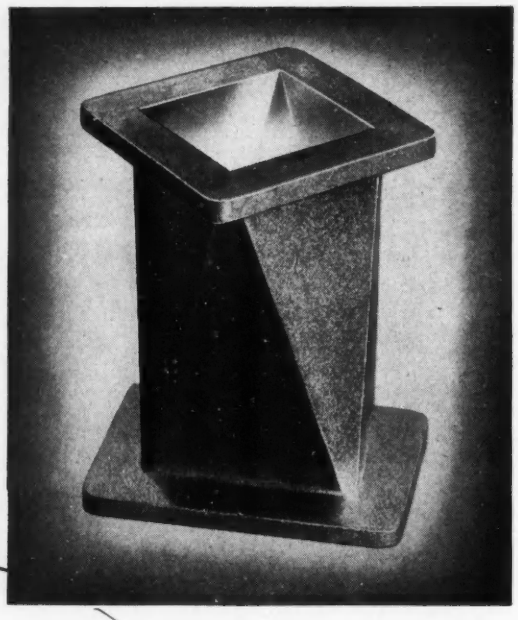
Castings of exceptionally fine surface finish and close dimensional tolerances are produced by our plaster processes in

Aluminium, Magnesium, and certain Copper-based Alloys.



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for Radar and communications

close tolerance

surface finish

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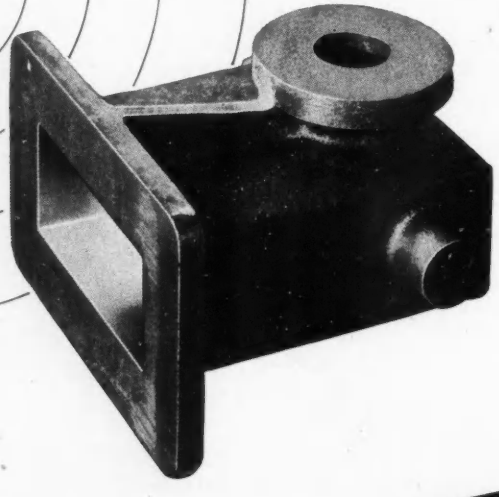

Comprehensive machine shop facilities, allied with our foundries, enable us to supply fully machined and assembled units to your order. Our representatives and technicians would be pleased to discuss your casting requirements.

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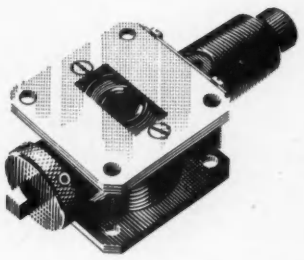
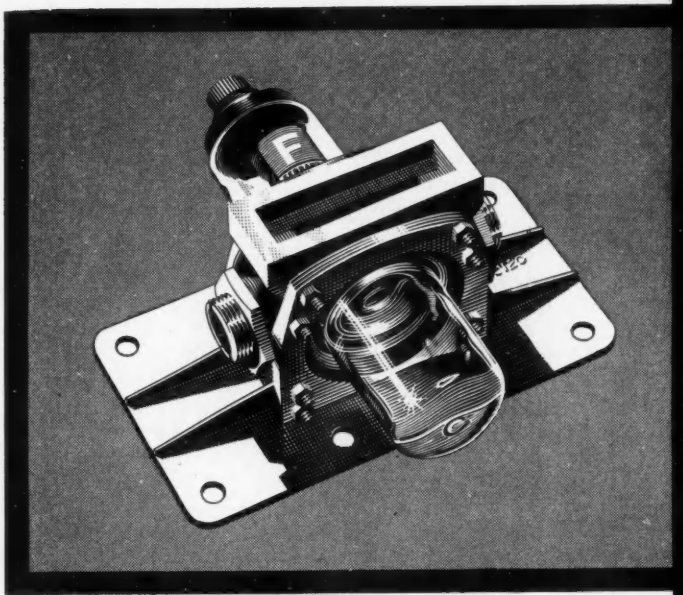
for Radar Equipment





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Ferranti Ltd. first made T. R. Cells in 1942 and by the end of the Second World War production was running at about 100,000 a year. The skill and experience attained during that period steadily increased until to-day the T. R. Cell research, development and production facilities of Ferranti Ltd. in Scotland are among the foremost in the world. The advice and co-operation of a highly skilled team of engineers is extended to all radar manufacturers.

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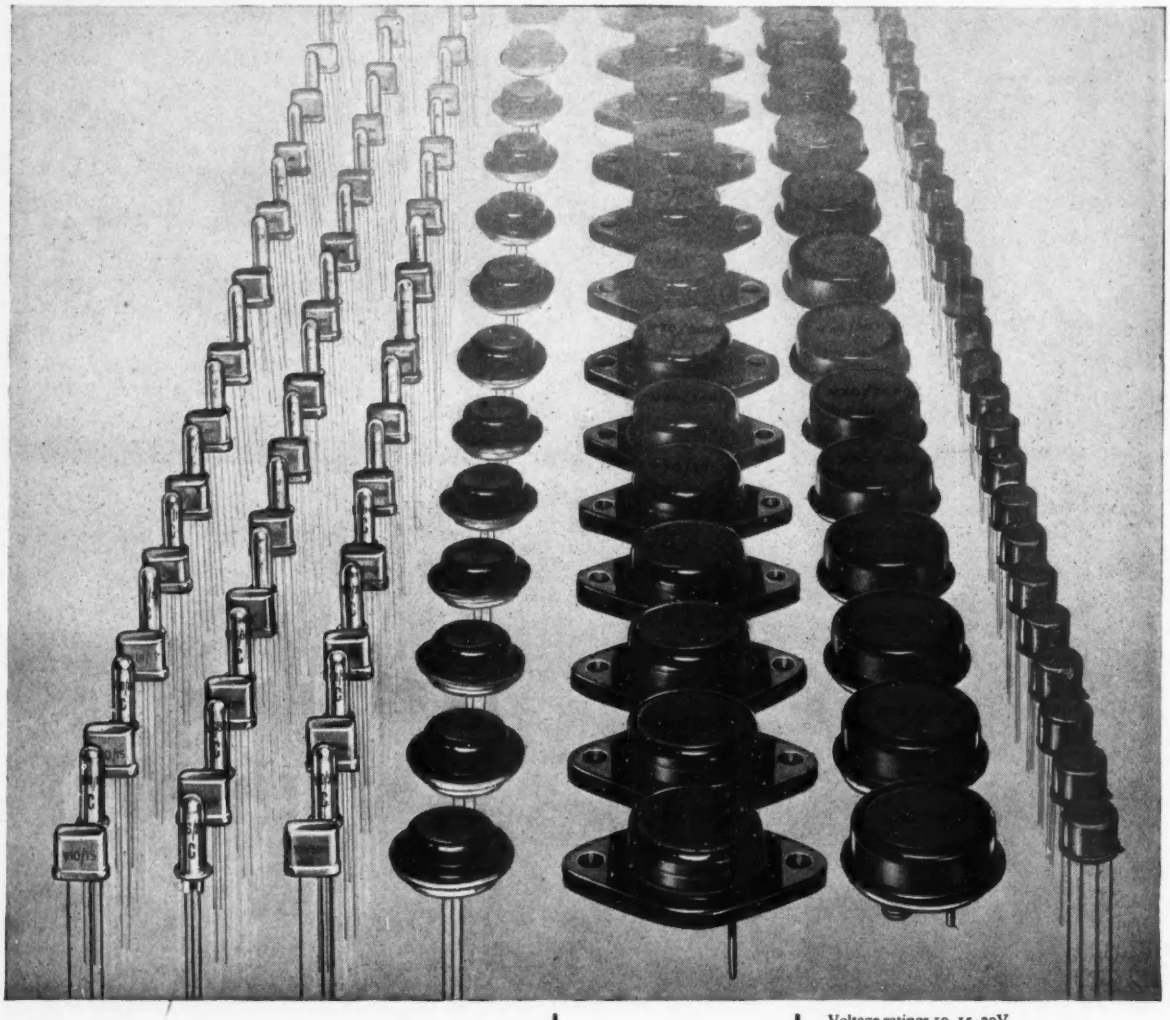

The Newmarket range includes them all

Switching	**V10/1S, V10/1SC V10/2S, V10/2SC**	Voltage ratings 10, 15, 20V. Switching Rise times down to .1μs (V10/1S), .2μs (V10/2S) Max. dissipation 125mW; Peak current 500mA. Rectangular or K1007/A1/D2 standard cylindrical style can
R.F.	**V6/2R, V6/2RC V6/4R, V6/4RC V6/8R, V6/8RC**	Voltage ratings 6, 10, 15, 20, 25V. Typ. frequency cut-offs 3, 5.5, 10 Mc/s Max. dissipation 125mW; Rectangular or K1007/A1/D2 standard cylindrical style can
A.F.	**V10/15A, V10/15AC V10/30A, V10/30AC V10/50A, V10/50AC**	Voltage ratings 10, 15, 30V. Typ. betas 20, 40, 75 Max. dissipation 200mW; Rectangular or K1007/A1/D2 standard cylindrical style can
I.P. (Intermediate Power)	**V15/20IP V30/20IP V60/20IP**	Voltage ratings 15, 30, 60V. Typ. beta 40 Max. dissipation 2W; Max. current 2Amp.
N.P. (Needle Power)	**V15/15NP | V30/15NP V15/30NP | V30/30NP**	Voltage ratings 15, 30V. Typ. betas 25, 40 Max. dissipation 15W; Max. current 6Amp. Standard Diamond (JEDEC E2—42) Base Cold welded case
P. (Power)	**V15/10P, V30/10P, V60/10P V15/20P, V30/20P, V60/20P V15/30P, V30/30P, V60/30P**	Voltage ratings 15, 30, 60V. Typ. betas 18, 24, 40 Max. dissipation 10W; Max. current 3Amp.
VHF Drift	**V15/20R**	Voltage rating 15V. Typ. frequency cut-off 30 Mc/s. Max. dissipation 75mW, Max. current 12mA. JEDEC T O-5—welded case.

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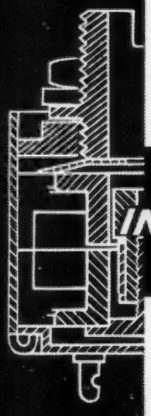
A NEW CONCEPT

IN POT CORE DESIGN



Mullard VINKOR range of adjustable pot cores gives you *outstanding* advantages

- Wide range of sizes
- Easily assembled
- Close tolerance permeability
- Precise and easy inductance adjustment
- Stability
- Single hole chassis mounting

Mullard Vinkors are the most efficient adjustable pot core assemblies commercially available. In addition to high performance, they have the distinct advantage of close tolerance permeability, thus enabling designers to precalculate to within ±3% the inductance of the core when wound. Final adjustment, taking into account normal capacitor tolerance, can be easily effected to an accuracy of better than 0.02%, by means of a simple self-locking device built into the core.

Write today for full details of the wide range of Vinkors currently available.

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VINKOR POT CORES

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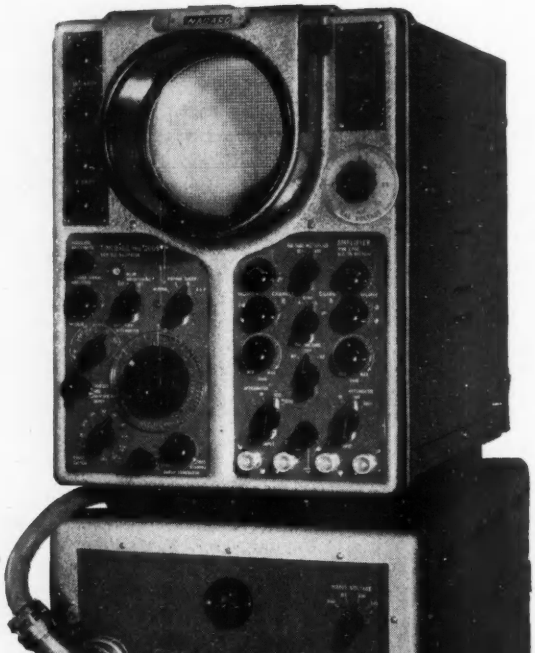
OSCILLOSCOPES are different

in that they provide facilities not otherwise available. By specializing in TRULY TWO CHANNEL CROs involving careful design, first class manufacture, and testing to a high standard of accuracy, we have now available two models incorporating many improvements—

MODEL DT103 (illustrated)—data sheet No. 4590

LOW FREQUENCY D.C. to 150 Kc/s (-3dB)
HIGH SENSITIVITY **-200 μV/cm maximum**
DIFFERENTIAL INPUT AND HIGH DISCRIMINATION in the two equal Y amplifiers
EQUAL X -Y DISPLAYS
WIDE RANGE LINEAR TIME BASE calibrated within 2%
SWEEP TIMES - 20 secs to 200 μsecs per 10 cm.
SWEEP EXPANSION x 5 switchable to either or both channels
TRIGGERING - sensitive and versatile
BEAM BRIGHTENING AND MODULATION facilities
INDEPENDENT X SHIFT displaying phase differences and giving exceptional facilities for comparison of two concurrent or related events
CRT SCREEN - 5 inches diameter, small spot size and freedom from geometrical errors in the display



MODEL DE103C—data sheet No. 3590

WIDE BAND - D.C. to 15 Mc/s (-3dB) or 21 Mc/s (-6dB)
RISE TIME - 0.024 μsecs. and no overshoot
LINEAR TWO CHANNEL TIME BASE calibrated within 2% and giving a minimum sweep time of 0.06 μsec./cm.
NO INTERACTION between channels - independent X shifts
TRULY SINGLE STROKE triggering on both channels
Y AMPLIFIERS similar in each channel and provided with VOLTAGE MEASURING facilities equally accurate on D.C. or A.C.

THE ABOVE COMBINATIONS OF FEATURES ARE EXCLUSIVE TO NAGARD CROs AND TO THE DISCRIMINATING USER THEY OFFER FACILITIES FOR THE DISPLAY AND MEASUREMENT OF A WIDE RANGE OF PHENOMENA TO HIGHLY ACCURATE STANDARDS.

REPAIR SERVICE—

—a first class service is now available for the repair and modernisation as far as possible of all earlier NAGARD instruments.

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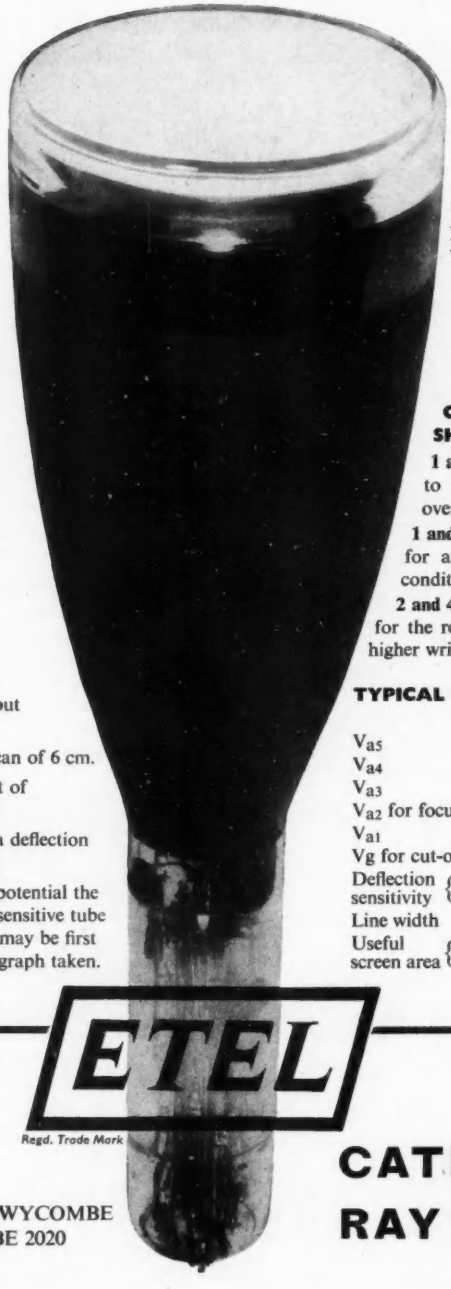
EXTRA HIGH SENSITIVITY

instrument tube 5CLP1



THE FIVE-INCH instrument tube 5CLP1 has a deflection sensitivity of 1.7V/cm with a useful Y scan of 6 cm. A special system of shielding the post deflection field from the deflection plates in this tube allows p.d.a. ratios as high as 15 to 1 to be used without pattern distortion. The extraordinary deflection sensitivity achieved with such high p.d.a. ratios profoundly affects oscillograph design. Bandwidths can be increased, amplifiers simplified and power supply requirements reduced. Write to the address below for full details of 'Etel' Instrument Tube type 5CLP1.

* P.d.a. ratios of 15 : 1 possible without pattern distortion.
* Sensitivity 1.7V/cm with useful Y scan of 6 cm.
* Sensitivity substantially independent of final p.d.a. voltages from 10 to 15 kV.
* High resolution—only 200 mV for a deflection of one spot-width.
* Versatility—by simply altering one potential the 5CLP1 may be converted from a very sensitive tube to a higher writing speed tube—pulses may be first examined and then a single shot photograph taken.

ABRIDGED DATA

This is tentative. Final data is being prepared.
5-inch flat faced precision oscillograph tube 5CLP1.

CAPACITANCES

X_1 to X_2 ... ... 2.5 pF
Y_1 to Y_2 ... ... 2.0 pF

One X plate to all other electrodes less other X plate 4.0 pF
One Y plate to all other electrodes less other Y plate 2.0 pF

COMPARE CONDITIONS SHOWN IN DATA

1 and 2
to see how deflection sensitivity is maintained over range of V_{a4} and V_{a5}.

1 and 2 with 3
for an illustration of a slightly lower sensitivity condition giving higher brightness.

2 and 4
for the reduction required in V_{a4} potential to achieve higher writing speeds.

TYPICAL OPERATING CONDITIONS

	1.	2.	3.	4.
V_{a5}	10kV	15kV	15kV	15kV
V_{a4}	10kV	15kV	15kV	3kV
V_{a3}	1kV	1kV	1.5kV	1kV
V_{a2} for focus	250V	250V	375V	250V
V_{a1}	1kV	1kV	1.5kV	1kV
Vg for cut-off	–60V	–60V	–90V	–60V
Deflection sensitivity y	1.7V/cm	1.7V/cm	2.5V/cm	2.5V/cm
Deflection sensitivity x	7V/cm	7V/cm	11V/cm	11V/cm
Line width	1mm	1mm	< 1mm	< 1mm
Useful screen area y	6cm	6cm	6cm	4cm
Useful screen area x	10cm	10cm	10cm	6.6cm

ETEL
Regd. Trade Mark

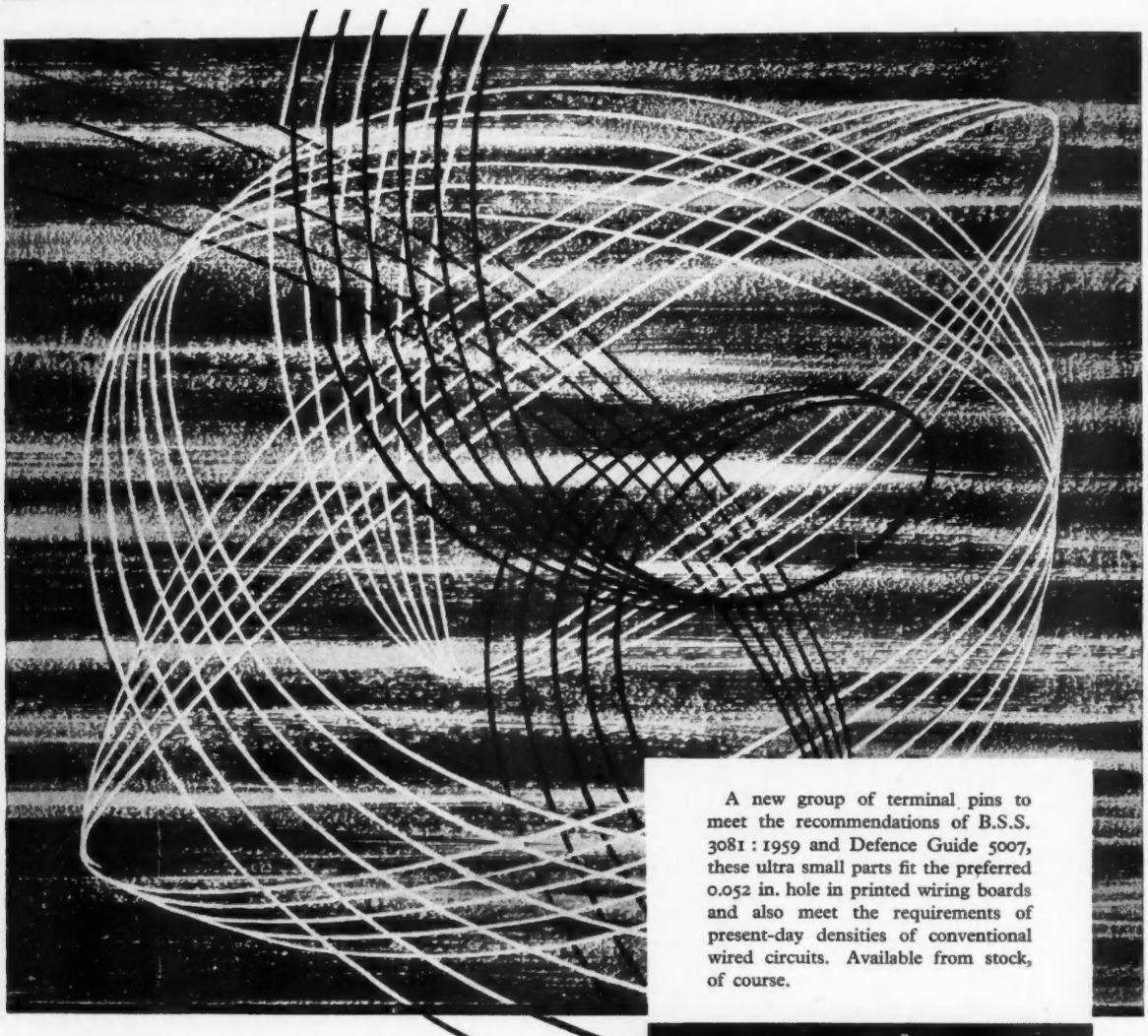
ELECTRONIC TUBES LIMITED
KINGSMEAD WORKS · HIGH WYCOMBE
BUCKS · TEL: HIGH WYCOMBE 2020

CATHODE RAY TUBES

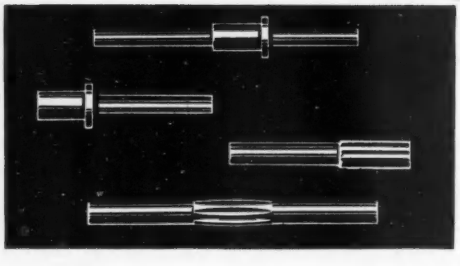
ETL 10

EE 15 102 *for further details*

precision products . . .



A new group of terminal pins to meet the recommendations of B.S.S. 3081 : 1959 and Defence Guide 5007, these ultra small parts fit the preferred 0.052 in. hole in printed wiring boards and also meet the requirements of present-day densities of conventional wired circuits. Available from stock, of course.



for quality components

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RODNEY ROAD PORTSMOUTH HAMPSHIRE Telephone PORTSMOUTH 35555

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PORTABLE

SMALL SIZE

LOW WEIGHT

INEXPENSIVE

A stable frequency source

A complete packaged oscillator unit

Stability 4 parts in 10^9

This new S.T.C. *complete* packaged oscillator unit represents a revolutionary step forward in crystal design. It is an extremely small unit for use as a laboratory reference or as the oscillator section of high quality equipment. The ruggedness of design together with the size makes possible a degree of portability hitherto unknown in this type of unit. Standard frequency is 5 Mc/s. Frequencies either side can be made to order.

STC COMPONENTS GROUP

Standard Telephones and Cables Limited

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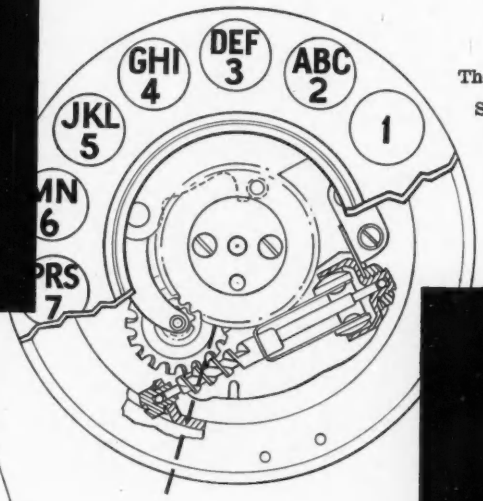
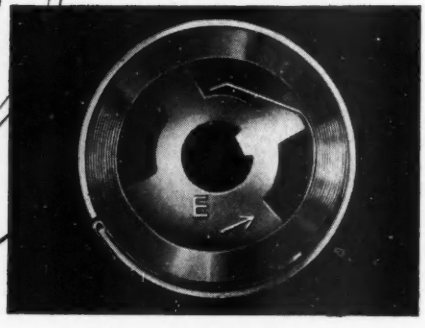
QUARTZ CRYSTAL DIVISION: HARLOW · ESSEX

Vital links in controlled movement

A body needs muscles to control movement in very much the same way as a mechanism needs springs. These vital links take the stress and strain of every day rigorous use — nature provides the muscles . . . SALTER provides the springs. Two centuries of experience and development in the manufacture of springs of every type have enabled us to keep ahead of the ever-changing requirements of industry.



The applications for SALTER springs are wide and varied — from heavy machinery to finely balanced instruments.



By courtesy of Ericsson Telephones Limited.

For springs with the highest reputation and top performance specify SALTER all-action springs.

SALTER ESTABLISHED 1760

GEO. SALTER & CO. LTD
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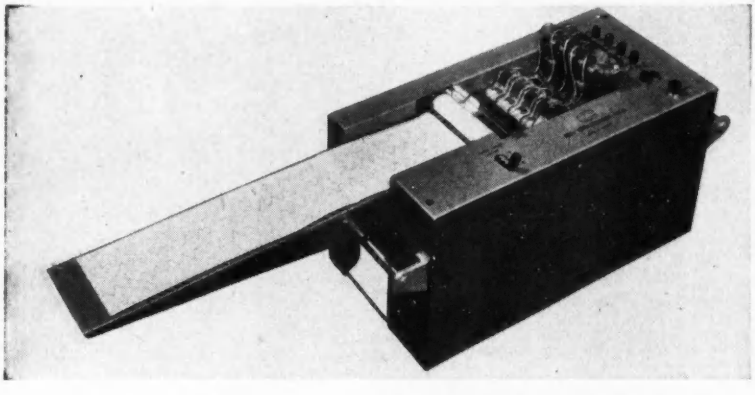
Oscillographic recording and testing equipment from Siemens Ediswan

If your work involves the study of fluctuating or intermittent phenomena, you should know more about these instruments.
The versatile High Speed Pen Recorder unit can be supplied singly or grouped in multiples of four up to a maximum of 16 channels and suitable amplifiers having a sensitivity of 1μV/mm a.c. or 10 mV/mm d.c. can also be supplied. These combinations are already making permanent economical records in industrial, physiological and physical research.

LOW FREQUENCY OSCILLATOR TYPE R.2125

The Low Frequency Oscillator is a general purpose R.C. instrument designed for testing, calibrating and setting up amplifiers, recorders, and low frequency wave analysers.

Frequency Range	1 c/s to 132 Kc/s
Frequency accuracy	2%
Output	Balanced push pull, 50 volts p.p. maximum on open circuit.
Attenuator	5 x 20 dB steps plus 0—20 dB continuously variable.
Output Impedance	600Ω—0—600Ω

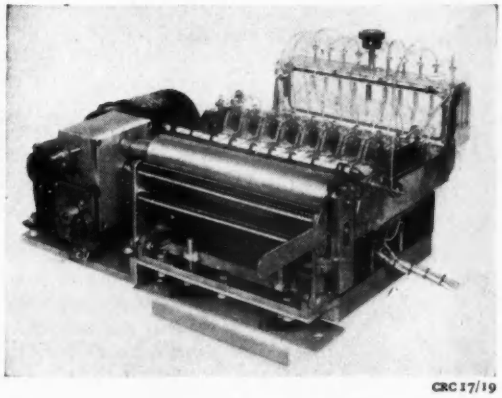


PORTABLE RECORDER TYPE EPR

The Siemens Edison Swan pen oscillograph is a portable 1 to 4 channel, high speed, direct ink writing, recorder.
The pen motor coil is 1450 ohms centre tapped.
Frequency response within 10% from 0–70 c.p.s.
Pen motors can be supplied with coil resistances of 230 ohms for use with transistors.
Maximum deflection of pen tip 4 cms peak to peak.
An electrical time and event marker is provided, writing on the lower edge of the paper.
The 4" wide paper is driven by a rubber covered capstan roller and speeds of 0·75 cms/sec. to 12 cms/sec. can be obtained.

8 CHANNEL PEN RECORDER UNIT

The pen motors incorporated in this unit are identical to those used in the 4 channel pen oscillograph.
The unit includes 8 pen motors fitted into a magnet block, two time markers, ink system and paper drive mechanism.
Three speeds of 1·5, 3 and 6 cms/sec. are available.
The unit is offered as shown in the photograph and is intended for incorporation into the users own equipment.
A 16 channel version of the above unit is also available.



We shall be pleased to send you particulars of these products

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An A.E.I. Company
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GM 5602

High Frequency Oscilloscope

Cathode Ray Tube: DH 10-78
Flat faced 10 cm tube, EHT - 4 kV
Vertical Amplifier: 3 c/s - 14 Mc/s
(-3 ± 1/2 dB)
Sensitivity 75 mV/cm,
Calibration accuracy 3%
Signal delay line 0.3 μsec.
Time base: 0.2 μsec/cm - 10 msec/cm
Calibration accuracy 3%
Horizontal magnification: X 2, X 5
Cathode-follower probe available.

The price - a pleasant surprise

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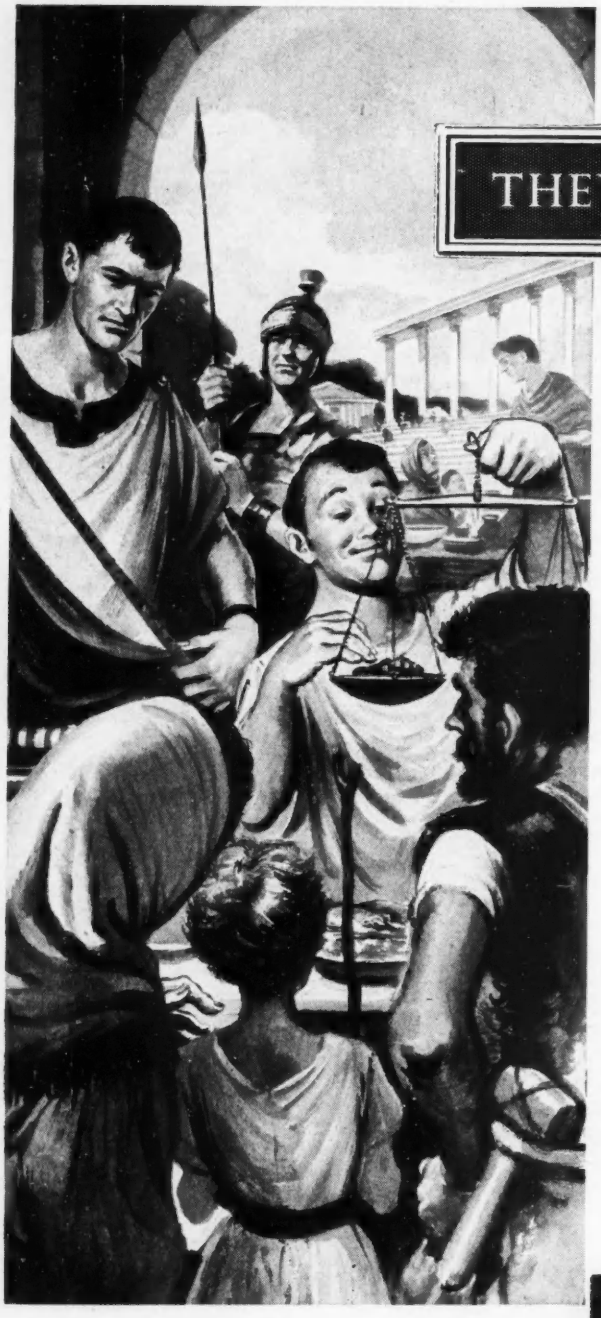

The market-place of a Roman town A.D.350.

THEY SET A STANDARD

IN the steps of the Roman legions that conquered Britain came the merchants and settlers. Secure under Roman law and administration, commerce and agriculture flourished, and Ancient Britain experienced a period of peace and prosperity it was not to know again until long after the Dark Ages.

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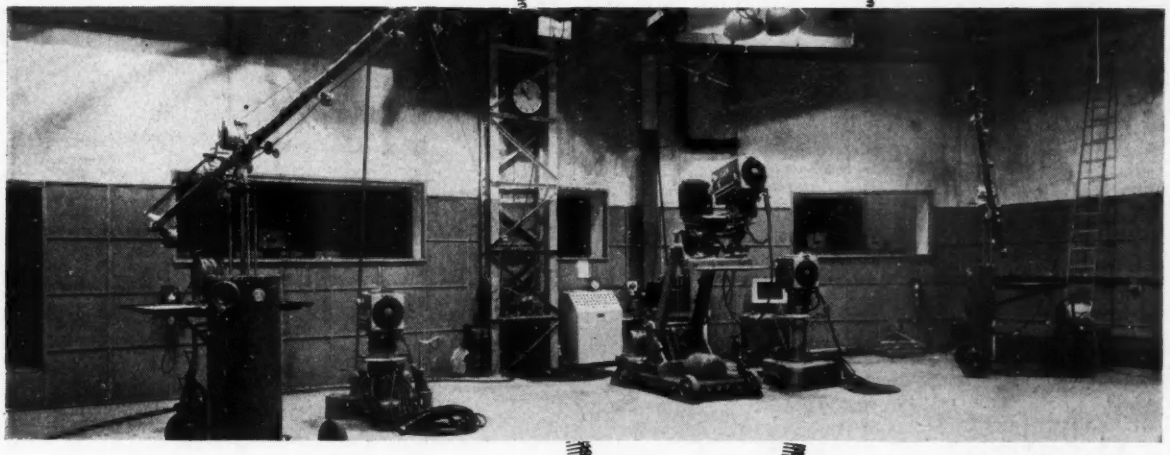
a comprehensive service



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We combine top-rate acoustic "know-how" with exceptional practical experience, particularly in designed acoustics for the Television, Film, Broadcasting and allied Industries and Electronic manufacturers, for whom we have carried out many important contracts.

Our service is both versatile and uncommonly complete. From test recordings in the field and subsequent measurement and technical analysis, it proceeds to intelligent acoustic planning and design, without which there can be no correct interpretation of a sound problem. Thence it extends to detailed specification and the final work of installation.

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In addition

- ★ *General acoustic correction for all types of special purpose rooms.*
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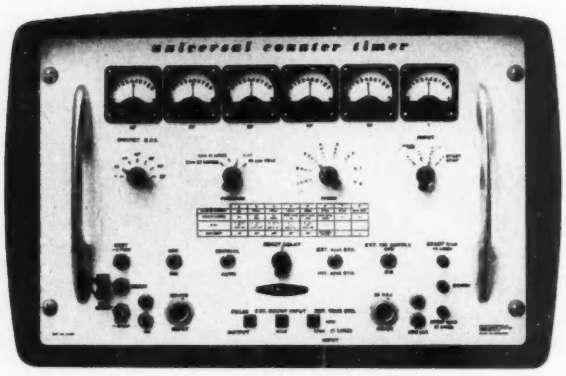
Transistorized UNIVERSAL COUNTER TIMER



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This fully transistorized portable equipment provides for a wide range of time and frequency measurement as well as facilities for counting, frequency division and the provision of standard frequencies. The facilities available are briefly listed below:

TIME/UNIT EVENT (1 LINE): For the measurement of the time interval between two occurrences in a continuously varying electrical function in the range 3μsec to 1sec. The time for 1, 10 or 100 such events can be measured.

TIME/UNIT EVENT (2 LINE): For time measurement in range 1μsec to 2777hrs. of any interval defined by a positive or negative going pulse in any combination.

EVENTS/UNIT TIME: For frequency measurement in range 30c/s to 1Mc/s over period of 0·001, 0·01, 0·1, 1 or 10secs. Crystal accuracy ±2 parts in 10^9/week. For mains or 12Vd.c. operation.

Full technical specification available on request.

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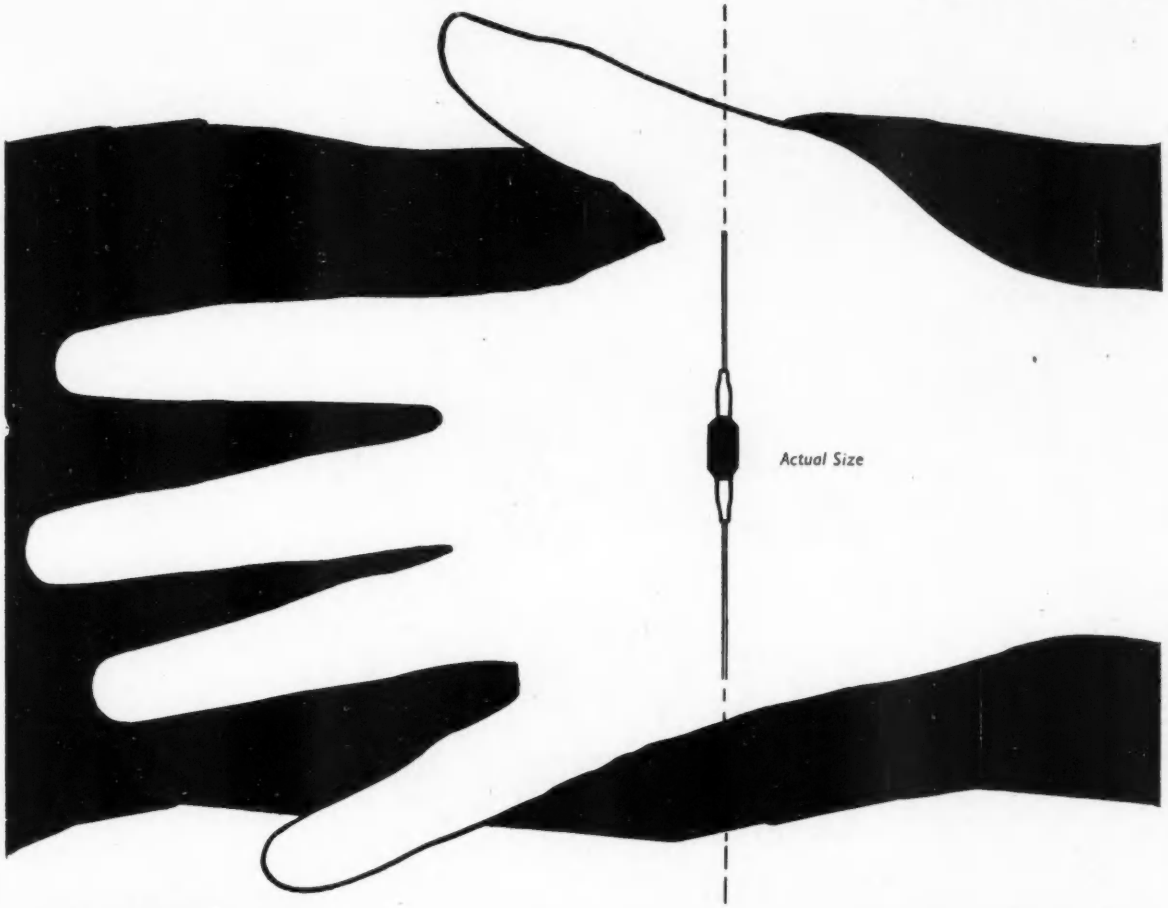

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- **Have a large dissipation for their size**
- **Are suitable for high temperature operation**
- **Have a low temperature co-efficient of voltage**
- **Are suitable for use as regulators, limiters, surge suppressors, and voltage references**
- **The first complete range of close-tolerance ZENER Diodes *available from production***

Characteristics and ratings of *SenTerCel* Zener Diodes are given in publication MF/103

Z2 SERIES ZENER DIODES		
±5% Voltage Tolerance (Red and Green Sleeves)	TYPE	NOMINAL VOLTAGE
	Z2A33F	3.3
	Z2A36F	3.6
	Z2A39F	3.9
±10% Voltage Tolerance (Red and Yellow Sleeves)	Z2A43F	4.3
	Z2A47F	4.7
	Z2A51F	5.1
	Z2A56F	5.6
	Z2A62F	6.2
	Z2A68F	6.8
	Z2A75F	7.5
	Z2A82F	8.2
	Z2A91F	9.1
±20% Voltage Tolerance (Red and Blue Sleeves)	Z2A100F	10
	Z2A110F	11
	Z2A120F	12
	Z2A130F	13
	Z2A150F	15

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W. STUBBS
Director-General Telecommunications, Malaya

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This important system, planned, manufactured and installed by S.T.C. for the Pan-Malayan Telecommunications Department, went into operation on 26th September. Its route of 270 miles, which cuts across some of the most difficult terrain in the country, will connect Kuala Lumpur and Seremban with Malacca, Tampin, Kluang, Johore Bahru and Singapore, and provides 600 telephone circuits with 240 telephone circuits on the spurs.

S.T.C. is very proud to have been chosen to play the major role in establishing this new super-high-frequency or microwave main-line trunk telephone network—a tribute to the company's wide experience in the development and manufacture of this type of system and to their proved ability to undertake complete installations in all parts of the world.

Standard Telephones and Cables Limited
TELECOMMUNICATIONS ENGINEERS
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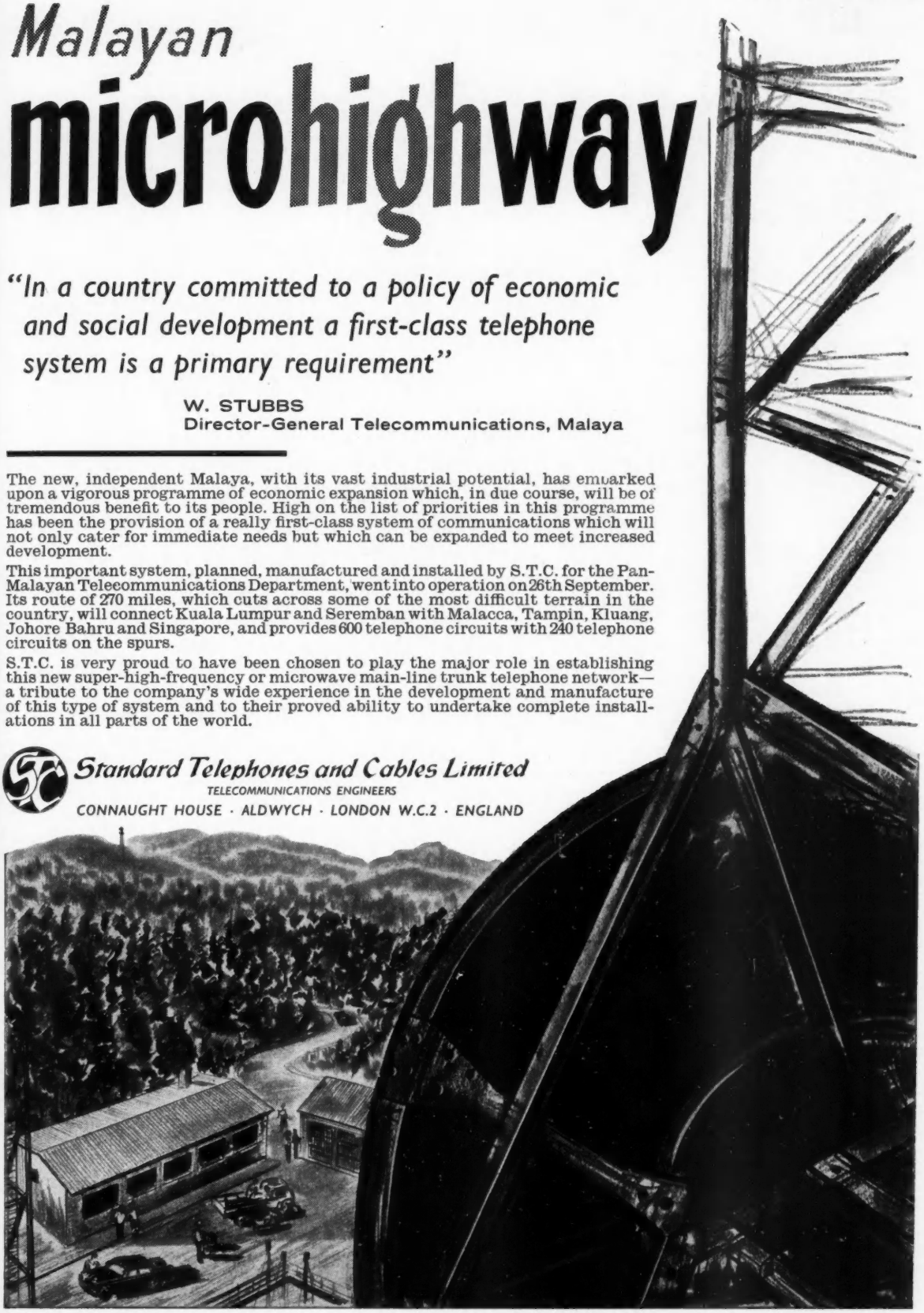

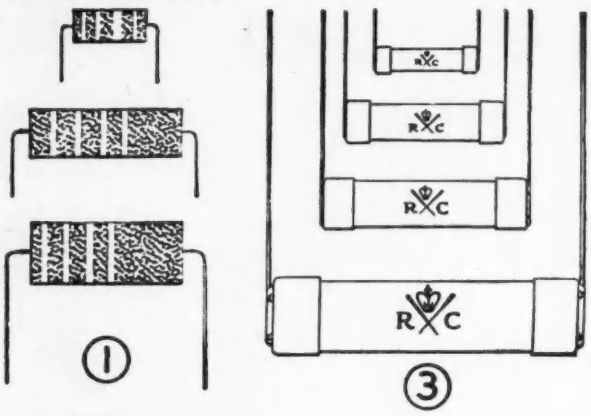

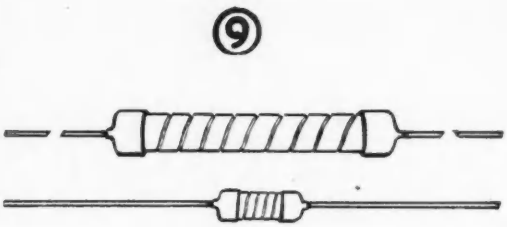

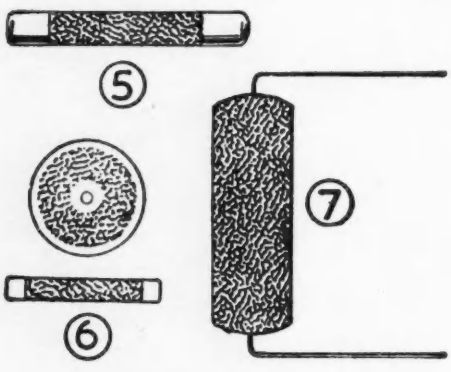

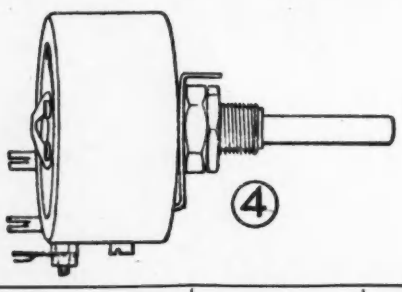

A SERVICE FOR DESIGNERS

The possibility of a component change—due to shortage of supplies, increased costs or failure to meet specific conditions—is a problem facing every designer of electronic equipment. However, one basic component can be 'tailor-made' from the start, for LAB will supply the precise type of Resistor required, ex stock *and* at the right price. Write for full technical data, prototype samples and price schedules to :—

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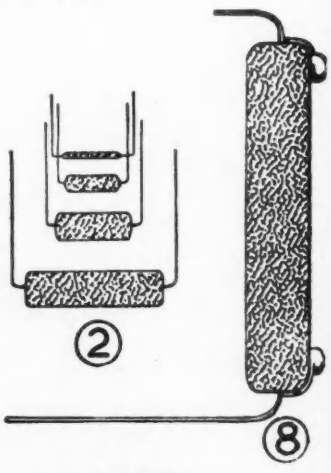

CARBON	WATTS	OHMIC RANGE	TOLERANCES ±
1. Solid	½ 1 & 2	10—10M	5% & 10%
2. Cracked	1/30—20	1—500M	5% & 10%
3. *High Stability	1/10—3	1—50M	0.5% 1% 2% 5%
4. Variable	¼	5K—2M	—
5. V. High Resistance	¼—3	50M—10^{11}	5% & 10%
6. V.H.F. (Rods & Discs)	1/10—1	10—1K	1% & 2%
WIREWOUND			
4. Rheostats	4—500	10—80K	—
9. Metal Oxide	¼—2	100—4.2M	1% 2% 5%
8. Vitreous	3—500	1—150K	1% 2% 5%
7. Cemented	1—15	1—25K	5% & 10%

*The ubiquitous blue (1%) grey (2%) "HISTABS"

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THAT the subminiature $^1/_{30}$th watt unit (2) is probably the smallest production Resistor made.

THAT almost non-inductive Resistors in cracked carbon are available up to 20 watts rating.

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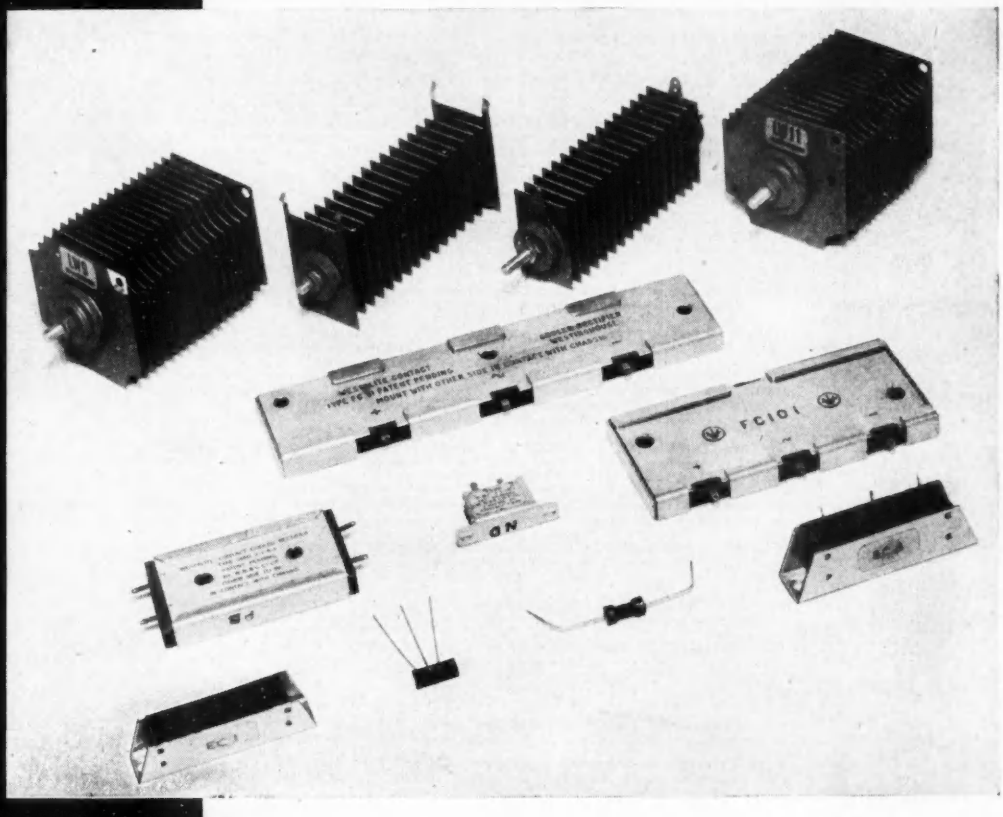
WESTINGHOUSE

for rectifiers *radio and television*



New and improved selenium double-voltage spindle-type rectifiers for normal mounting and printed circuits.

New and improved contact-cooled and edge-contact-cooled rectifiers are now available for h.t. supplies to radio and television receivers.

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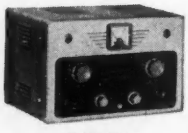

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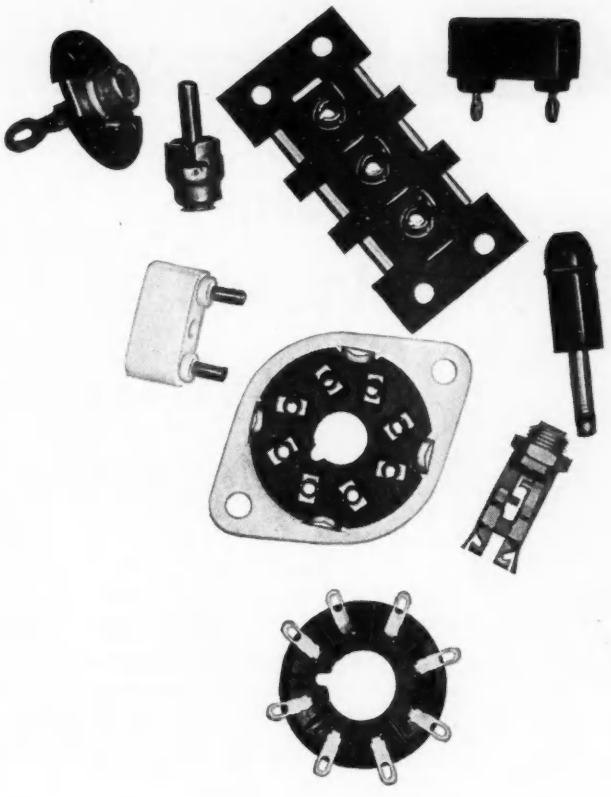

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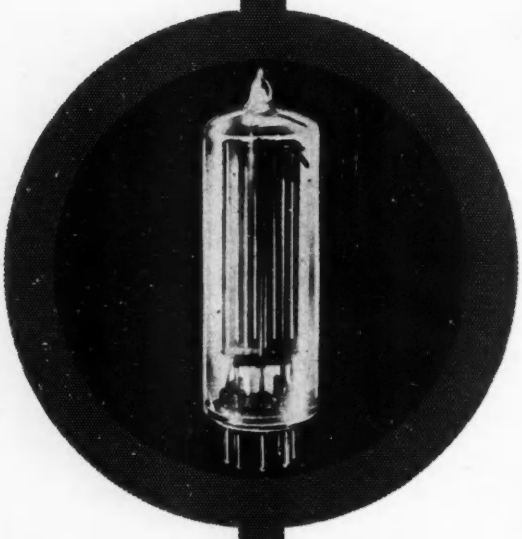

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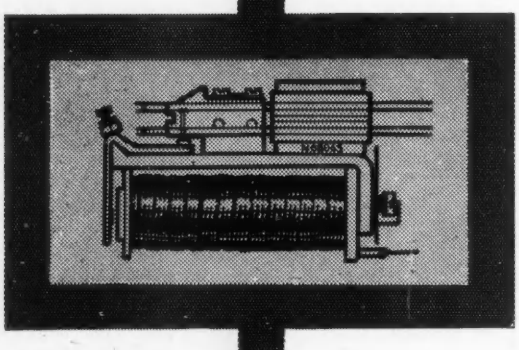

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ELECTRONIC ENGINEERING

VOL. 31 No. 381

NOVEMBER 1959

Commentary

THE proposal included in the manifesto of the two major political parties to appoint a Minister for Science was one of the least controversial issues in the recent General Election in this country, but the fact that both parties had put it forward is perhaps an acknowledgment that such a measure was long overdue.

The new Government has obviously felt some sense of urgency about this matter for one of its first acts has been to issue an Order in Council creating Lord Hailsham as the first holder of this very important office and transferring to him the functions previously exercised by the Prime Minister under the Atomic Energy Acts. The same Order substitutes the Minister for Science, who, in addition will retain the office of the Lord Privy Seal, "for the Lord President of the Council as member and chairman of the Privy Council committees for the five research councils, and transfers to him the functions of the Lord President in relation to those councils and certain other organizations".

The terms of reference are in themselves explicit enough but in amplification of them it has been stated that Lord Hailsham, in combining the duties of Lord Privy Seal and Minister for Science, "will be responsible to the Government for the Council for Scientific and Industrial Research, the Medical Research Council, the Agricultural Research Council, the Overseas Research Council and the Nature Conservancy. Besides exercising the ministerial functions under the Atomic Energy Acts he will exercise general supervision over the programme of space research at present being devised under the direction of the steering group presided over by Sir Edward Bullard".

He will be responsible for the broad questions of scientific policy and will receive assistance from the Advisory Council, but he will not of course be answerable for the various Government scientific establishments, the responsibility for which will remain with the ministers concerned.

In the short time that he has been appointed Minister for Science, Lord Hailsham has been able to do no more than survey the situation which the new office presents, but his assessment given at a recent Press Conference appears encouraging.

He is, on his own admission, no scientist but this in no way detracts from his suitability. On the contrary, a non-scientist, providing he has sufficient appreciation of the broad problems and can give to each its proper weight and importance, is, in our view, an ideal candidate.

He has, in addition, cleared the air to a considerable extent in stating what he is not expected to be. He will not be a Master of the Queen's Rockets or a super Minister of Power, Transport, Agriculture or Health, neither will he be a Chancellor of University Chancellors.

This negative attitude may give the impression that the appointment is no more than a piece of political window dressing designed to fulfil a promise made in the heat of an election and that everything will go on in the same way as it did before, but this is far from being the true state of affairs.

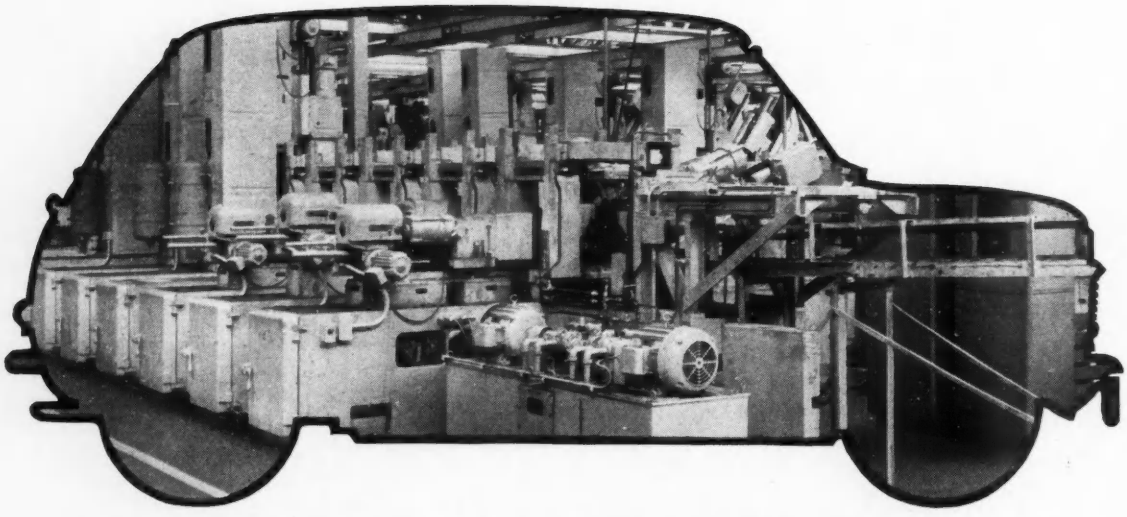
In this age when scientific developments make a greater impact on our lives than ever before, the need for this new office is real and the new Minister has made his purpose clear—"to make the voice of science coherent and articulate under Government encouragement, and in one real sense to make science self-governing under Government inspiration".

It has been made clear that while he must remain interested in the more glamorous and newsworthy fields such as space research, he has every intention of striking a proper balance—a most difficult task—between research which is carried out simply and solely for national prestige, and pure fundamental research of the kind in which this country has always excelled.

It is tempting to be the first country to put a man into outer space, but to enter this race would be financially disastrous to us. The mere projecting a man into outer space, keeping him alive there and bringing him safely back to earth would require a fantastic amount of effort and it is doubtful whether any worthwhile scientific results would be achieved. Moreover, it is acknowledged that most, if not all, the data required in outer space can be obtained by the use of instruments alone and it appears that this is the direction in which the British effort will be concentrated.

All must wish the new Minister well in his determination to make British science in all its fields an instrument of peaceful progress, for the rewards are enormous. If he succeeds he will have contributed in no small measure to the peace and prosperity of the world, and raised the esteem of this country to the greatest of heights.

ACCESS *(Austin Cold-Cathode Electronic Switching System)*



A Static Switching System using Cold-Cathode Tubes

By R. W. Brierley*

The great strides taken recently in automating production processes has resulted in very complex control systems. The majority of these are of the ON-OFF *type using relays as the logical elements. Above a certain level of complexity, it becomes difficult to maintain a high standard of operating efficiency with such equipment. A search has begun for more reliable alternatives to the electro-mechanical relay and systems using static devices have started to emerge. One such system, using cold-cathode tubes, is described.*

(Voir page 706 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 711)

The rate of development of transfer machines, conveyor systems and other forms of so-called automation has been so rapid in the past few years that their control systems have now become exceedingly complex. This rate of development shows no sign of abating and, while the existing, well-known control methods employing relay circuits are capable of almost unlimited extension, there comes a stage, nevertheless, when it is extremely difficult in practice to maintain the required standard of reliability. Relays, even in the best of enclosures, all too frequently fall prone to the hazards of industrial usage and, if the future control systems are to have increased reliability, then it would seem that some substitute, either partial or complete, should be found for the conventional relay.

Awareness of this fact has resulted in the development of static switching systems in which the contacts and moving parts of the electromechanical relay have been replaced by the purely electrical switching action of such devices as magnetic amplifiers and transistors. Surprisingly, however, there is little indication that any real attempt has been made to exploit cold-cathode tubes for this purpose except in automatic telephony and, lately, in digital computers. Due almost entirely to pioneering development in the former field, a wide range of such tubes is available with inherent characteristics that are undoubtedly suited to the application. These tubes are compact, self-indicating and extremely reliable and, while it cannot be said that their life is infinite, experience has shown that it is compatible with that of production machinery. Moreover, being purely two-state devices they are, in a logical sense, ideal switching elements for systems which derive their inputs from binary devices such as limit switches and push-buttons.

Since the great majority of machine tools and material handling systems in existence today do, in fact, function with this type of input, a static switching system based upon cold-cathode tubes should be entirely practicable. Indeed, such a system is already in use controlling nine transfer machines, and in this article it is proposed to give some idea of the simple yet versatile circuits that have been used in place of electromechanical relays.

In spite of the merits of static switching, however, it is highly improbable that the electromechanical relay will ever be entirely displaced. The present cost of a static system for a large and complex installation is less than for one employing relays but the reverse would be true for simple schemes. This fact, coupled with many others, suggests that the two systems will tend to be complementary, each having its own sphere of application yet, in many instances, being used together to obtain the best balance of first cost, reliability and, most important of all, speed of maintenance.

* *The Austin Motor Co. Ltd.*

The above photograph shows a typical transfer machine within the outline of an 'Austin Seven'

Such is the hybrid system to be described, where it will be seen that relays and contactors have been used wherever it is necessary to switch large powers for solenoids and motors. These operations could well have been accomplished with magnetic amplifiers but both cost and bulk would have been a considerable embarassment. Similarly, push-buttons and limit switches have been retained though, in the case of the latter, it is chiefly the cost of the static equivalent that hinders its replacement. Simple inductive proximity switches have been used on transfer machines in place of some limit switches for over five years now and their initial cost, which is approximately four times that of a sealed limit switch, has been well repaid by what is virtually 100 per cent reliability.

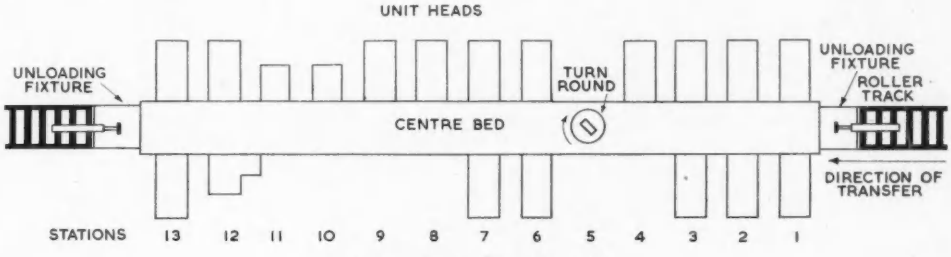


Fig. 1. Plan layout of transfer machine

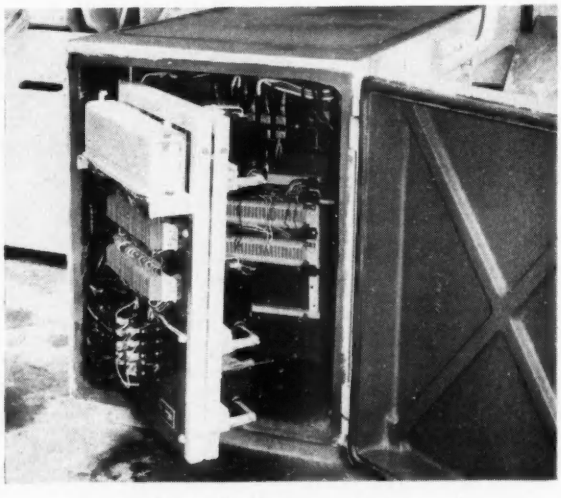


Fig. 2. Unit head control panel

Description of Transfer Machine

The type of transfer machine to which the ACCESS system has been applied is illustrated at the top of page 646. This machine forms part of a continuous machining line and is unattended in the sense that it automatically loads and unloads itself and controls the flow of components to the succeeding machine. It is some 30 yards long and has 20 machining stations in which cylinder blocks are drilled, faced, milled and bored. Certain stations, both within and at the end of the machine, re-orientate the block in 'turn-over' or 'turn-round' fixtures so that the appropriate surfaces are presented to the machining heads at the succeeding stations.

As shown in Fig. 1, a typical machine consists basically of a centre bed along which components are indexed or 'transferred', and a number of side beds on to which are fixed the unit head machine tools. By means of a standardized system of construction, these unit heads can be mounted horizontally, vertically, or at any intermediate angle. Every unit head has its own standard control panel, housed usually in a cubicle in the side bed, Fig. 2, and the circuits of these panels are so arranged that, once started by a signal from the Group Control, the unit heads automatically carry out their appropriate machining cycles with the various movements pre-set by adjustable limit switches.

The cycle naturally varies according to the type of machining required; a drilling cycle, for example, consisting of the sequence:

(a) Fast approach of drills to component
(b) Slow drilling feed to correct depth
(c) Fast return to starting position

Similarly a tapping cycle would be:

(a) Fast approach of taps to component
(b) Slow tapping feed to correct depth
(c) Slow reversal of taps till clear of component
(d) Fast return to starting position

Presuming that a component is already waiting in the LOAD station, the complete cycle of operation of one of these machines is as follows:

(1) TRANSFER — all components indexed forward one station.

(2) CLAMP — all components at machining stations clamped rigidly in accurately-located positions.

(3a) START HEADS — all unit heads signalled to start machining.

(b) LOAD and UNLOAD — a new component fed into the LOAD station and a machined component ejected from the UNLOAD station.

(4) UNCLAMP — all components at machining stations unclamped in readiness for the next transfer.

The power for all the various movements just outlined is either electric, hydraulic or pneumatic. The majority of unit heads, together with a swarf-collecting conveyor and input and output roller tracks fall into the first category, the transfer, clamping, loading and unloading mechanisms are hydraulic and, at those stations which precede a tapping operation, there is usually a pneumatic unit head that feeds a hollow probe into the already-drilled hole. This is not only to check that it has been fully drilled but also to blow out swarf.

Clearly, all these various movements need to be position sensed and limit or proximity switches are provided at the

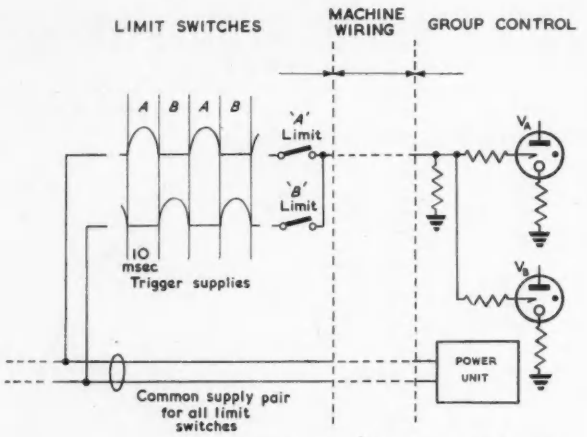


Fig. 3. Use of one conductor for two limit switches

essential points for this purpose. Frequently, as in the case of the transfer hydraulic cylinder where it is necessary to know only if it is either fully extended or retracted, merely two limit switches are required for each particular movement. Nevertheless, the total number of such switches is considerable (over 200 on the machine illustrated) and it will be realized that, together with the many other circuits involved, both the wiring and interlocking of these limits can pose many problems.

Access—Basic Considerations

The electrical control system of a transfer machine can be divided roughly into three parts:

(a) The individual control panels for each unit head machine tool.

(b) The signal circuits receiving information from input devices such as limit switches and push-buttons.

(c) Sequence circuits for correlating this information and initiating the appropriate action.

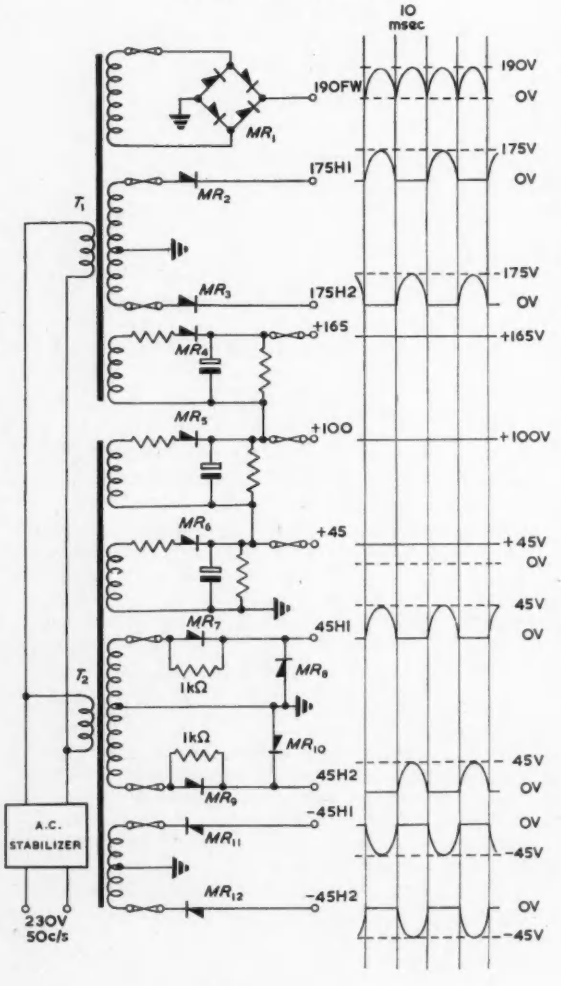
The panels referred to at (a) are a standard type using BPO 3000 type relays and 50V d.c.-operated contactors. They have been used on many previous machines and their circuits which are quite conventional, do not warrant description. Sections (b) and (c), however, form a large part of what is known as the Group Control of the machine and it is to this unit that ACCESS has been applied.

In a conventional control system, the outputs from the various limit switches terminate in the Group Control where relays are energized in accord with the state of the switches. For a cold-cathode tube to function analogously to the relays, obviously it must conduct while a limit is closed and extinguish when a limit is opened. Further, if the switch is to control conduction via a trigger electrode, as in a triode or tetrode, then the anode must be fed from a periodically-interrupted supply. Since a high-speed of response is not usually essential in this type of machine control, a half-wave rectified anode supply at mains frequency would seem the obvious and simplest choice. Indeed, supplies of this form are used almost exclusively throughout the equipment, not only for the anodes of the tubes but also for the trigger signals from the limit switches. The reason for this is that, with a half-wave rectified anode supply, the tube is, in effect, phase-conscious and will conduct only to those trigger signals that occur in phase with the anode voltage. This leads naturally to the attractive situation represented schematically in Fig. 3 where, by using two anode and trigger supplies, each of opposite phase, the signals from a pair of limit switches can be transmitted to the Group Control over one conductor. Only the *A* limit will fire V_A, only the *B* limit V_B.

Since most of the other limit switches on the machine also work in logical pairs, e.g; TRANSFER BAR FORWARD—TRANSFER BAR BACK, TURNOVER UP—TURNOVER DOWN, they, too, can be arranged to signal over single conductors and thus halve a considerable proportion of the total wiring.

In the Group Control, many other circuit arrangements such as this occur, chiefly as a result of the use of half-wave supplies. It might not be illogical, therefore, to describe first the power unit that produces them.

Fig. 4. Access power unit



Power Unit

The complete circuit shown in Fig. 4. A simple code

has been adopted to designate the outputs and this, together with the relevant waveforms is shown on the circuit.

Wherever the suffix H1 occurs, it denotes a half-wave rectified supply of one phase (arbitrarily chosen) whereas the suffix H2 represents a similar waveform but of opposite phase. FW represents a full-wave rectified supply. The numerical value of any particular output is the peak voltage referred always with respect to earth while the negative sign which prefixes the two outputs -45H1 and -45H2 indicates that these two supplies are negative-going. D.C. outputs such as +165, +100 and +45 have no suffix. As will be apparent later, the 190FW, 175H1, 175H2 and +165 are anode supplies, the +100 and +45 are for biasing arrangements and the 45H1 and 45H2 are supplies for the limit switches. In conjunction with the latter, the two negative outputs −45H1 and −45H2 are used for operating diode indicator tubes.

All the rectifiers are of the silicon junction type, their excellent regulation, coupled with the stabilized a.c. input, giving constant output voltages in the simplest manner.

Possibly only one point in the circuit calls for comment and that concerns the shunt rectifiers of the 45H1 and 45H2 outputs. Without these two rectifiers MR_8 and MR_{10} and their associated 1kΩ resistors, the output impedance of the supplies is high during the half-cycles when MR_7 and MR_9 are cut-off and feedback of unwanted signals can occur. MR_8 and MR_{10}, however, conduct heavily to the negative half-cycles as passed by the 1kΩ resistors and serve effectively to clamp the output to earth while MR_7 and MR_9 are cut-off.

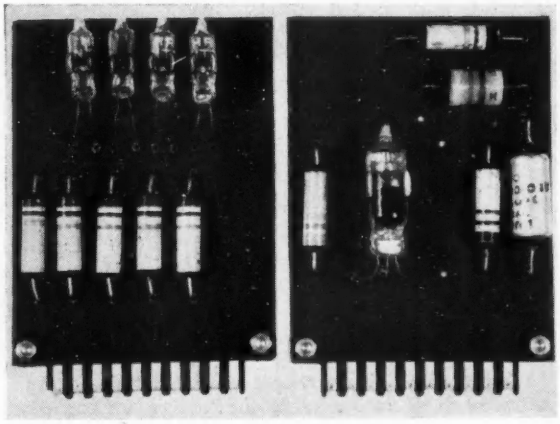


Fig. 5. Typical plug-in circuit elements

Circuit Description

All the circuits involved in this static system are built up from plug-in logical elements, two typical examples being illustrated in Fig. 5. There are in all twenty different elements and experience has shown that practically any control scheme of this type can be constructed with them. Undoubtedly, the number of different types could have been drastically reduced but the apparent simplification would have been far outweighed by the larger number of units required to achieve the same result. As it is, only ten basic printed boards are required, each board forming the basis of two or more logical elements.

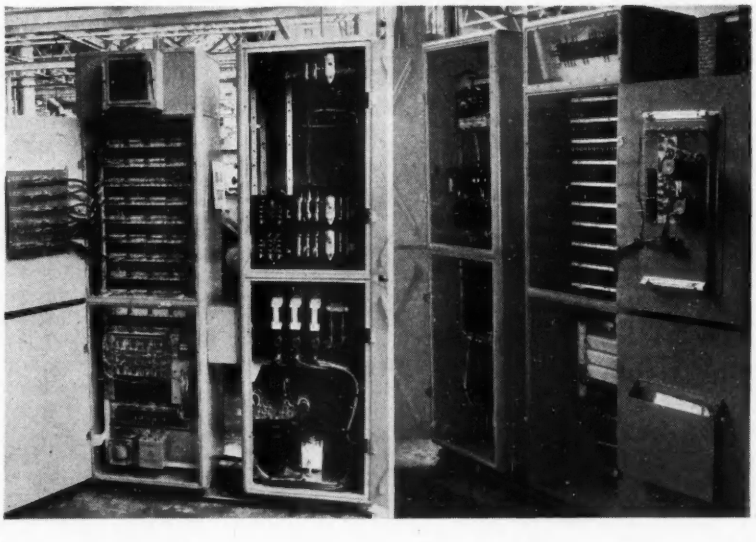
These elements will now be described and, in the diagrams that follow, their individual nature has been clearly shown since this not only aids description but also illustrates the ease with which a complete circuit is evolved. Some idea of the way in which the elements are mounted and wired can be gained from Fig. 6.

The cold-cathode tubes used in these units are Hivac types NT2, XC18 and XC23 and their main characteristics are given in Table 1.

TABLE 1
Main characteristics of cold-cathode Tubes NT2, XC18, XC23

	NT2	XC18	XC23
Minimum main gap breakdown voltage		210V	200V
Nominal main gap maintaining voltage		73V	67.5V
Nominal control gap breakdown voltage		68V	70V
Maximum cathode current		1mA	7.5mA
Nominal strike voltage	80V		
Nominal maintaining voltage	55V		
Maximum current	1mA		

Fig. 6. Internal construction of group control



ELEMENT R1

Fig. 7 is the circuit of the first standard element used in the ACCESS system.

An input signal, either 45H1 or 45H2, at terminal 1 is d.c.-restored upon the +45 normally present at terminal 4 and fires the trigger-cathode gap of the XC18. If terminal 6 be connected to 175H1, the main gap will fire only when a 45H1 is present. Similarly, if the anode is fed from 175H2, the main gap will fire only with a 45H2 signal. By removing the +45 bias from terminal 4, the tube will not fire with either signal.

When, however, the tube does fire, it develops across its cathode resistor a signal of 100V peak amplitude of whichever phase is applied to its anode. This is then fed out on terminal 9 to further elements.

It will probably be realized now that the use of half-wave rectified supplies produces a set of operating conditions that, in effect, combines the advantages of both well-known methods of firing cold-cathode tubes, namely; 'pulse-plus-bias' and 'd.c. voltage transfer'. For as long as an input signal persists, the tube fires 'continuously' to each positive half-cycle of its supply yet the facility of controlling conduction via an auxiliary input, the bias, remains.

ELEMENT RC4

The circuit, shown in Fig. 8, is used in conjunction with an R1 unit when a number of independent outputs are required from one input.

The 100V output from R1 is applied to terminal 1 and strikes the NT2 diodes. With a maintaining voltage of 55V four entirely independent signals of 45V peak amplitude are thus available at terminals 2, 4, 6 and 8.

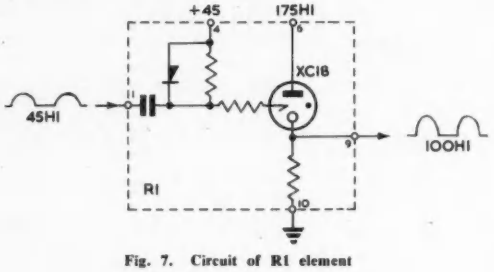


Fig. 7. Circuit of R1 element

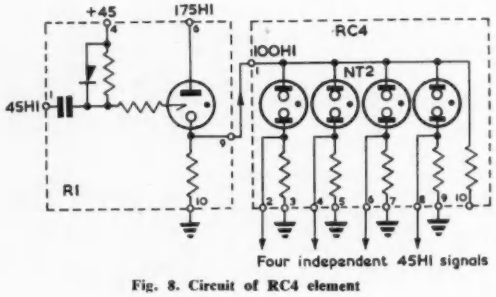


Fig. 8. Circuit of RC4 element

A similar element, RC2, is available with two diodes for when only two outputs are required.

It was mentioned earlier in connexion with the R1 element that the circuit operates in the pulse-plus-bias mode. Switching the bias gives an added control facility and this is frequently accomplished as shown in Fig. 9.

Here, in a typical transfer machine arrangement, +45 biases for a number of independent R1 circuits are provided by one RC4 element when +100 is switched to its terminal 1 by a single pole of an AUTO/MANUAL switch. In the MANUAL position the biases, and hence the firing of the R1 tubes, are brought under the control of the two MANUAL push-buttons. No matter how complicated the circuit, virtually any number of tubes can be controlled in this manner with the simplest of switching arrangements.

It is perhaps worth noting here that the outputs from both the R1 and RC4 type circuits are substantially independent of load. This follows naturally since the output voltages are derived from stabilized supplies via gas-discharge tubes which are themselves constant-voltage devices.

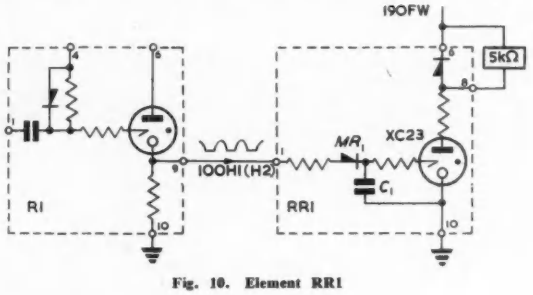


Fig. 10. Element RR1

ELEMENT RR1

This circuit, Fig. 10, can also follow an R1 unit and operates a BPO 3000 type relay for the switching of motor contactors and solenoid valves etc.

The 100V peak signal from R1 enters on terminal 1 and is converted to direct current by the rectifier and capacitor, MR_1 and C_1. The XC23 thus fires to every half-cycle of the 190V full-wave anode supply, irrespective of the phase of the input, and energizes the relay. While a half-wave anode

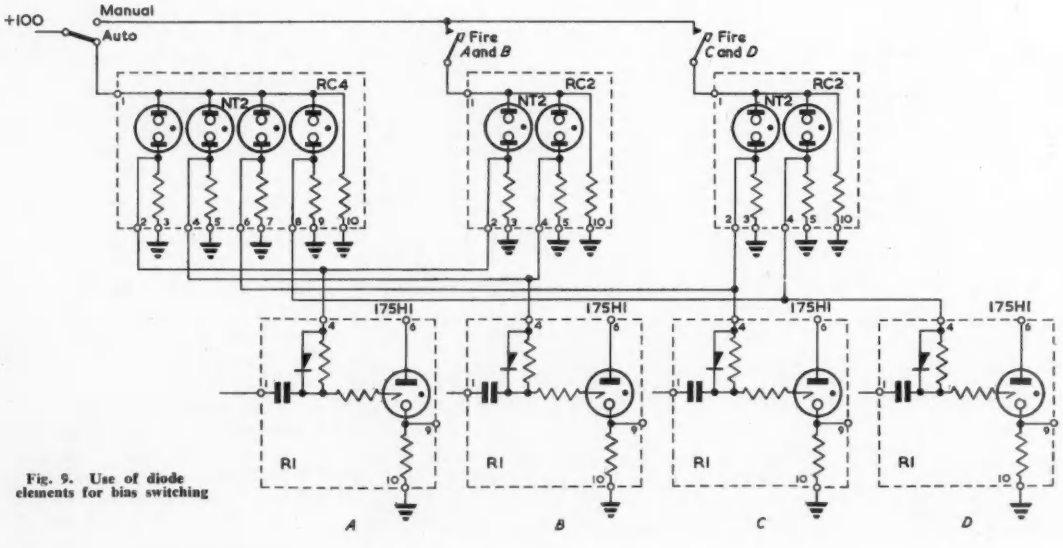


Fig. 9. Use of diode elements for bias switching

supply could have been used for this circuit, it would have led to high peak tube currents to ensure satisfactory relay operation.

ELEMENT PC1

Incoming signals from limit switches can be of two types, 45H1 or 45H2. Frequently, it is desirable to change automatically from one phase to the other and the element PC1, Fig. 11 is used for this purpose.

The limit switch first fires an R1 whose output, 100V of, say, phase H2, is then fed to terminal 1 of the PC1. The rectifier and capacitor, MR_1 and C_1, convert this signal to direct current and the XC18 conducts to each half-cycle of the 175H1 supply to which terminal 6 is connected.

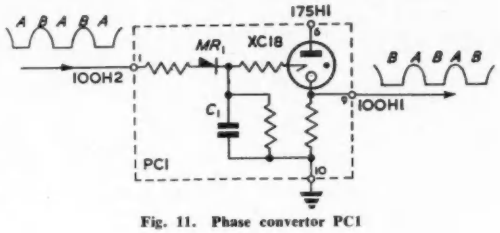


Fig. 11. Phase convertor PC1

The circuit thus accepts a 100H2 input and delivers a 100H1 output, or vice versa.

ELEMENT H1

Instances occur where it is required to fire a tube with one signal and hold it on with another. This mode of operation is accomplished as shown in Fig. 12.

A 100H1 or 100H2 signal from an R1 element is applied to terminal 3 where it is converted to direct current by the rectifier and capacitor MR_1 and C_1. If, now, a 45H1 (or H2) signal is present at terminals 1 or 2 of the AND matrix MR_3, MR_4 and R_4, then a 45H1 (or H2) signal is fed out on terminal 9 to fire a following R1 element. Once fired, this R1 element feeds back 100H1 (or H2) from its cathode to terminal 8 of the H1 element, where it is converted to direct current in the same manner as the original incoming 100V signal. This latter signal may now disappear but the second R1 circuit will remain on, due solely to its own feedback and the hold-on signal present at terminals 1 or 2, or both. When the hold-on signal terminates, the second R1 tube will extinguish.

ELEMENT GR1

In some cases it is necessary to operate tubes with a d.c. anode supply so that they will fire to the closing of a limit and remain fired as a temporary memory. With such a d.c. supply, the cold-cathode tube is no longer phase-conscious and it becomes necessary to introduce this feature into the trigger circuit. Such an element is the GR1, shown in Fig. 13.

Assuming that terminal 6 is connected to +165, terminal 4 to +45 and terminal 5 to +100, then with either a 45H1 or 45H2 signal at terminal 1 only, the XC18 will fire and remain fired until the anode supply is disconnected. If, however, it is required that the circuit respond only to 45H2 signals even though signals of the opposite phase may at some time or other be present, then terminal 2 of the input

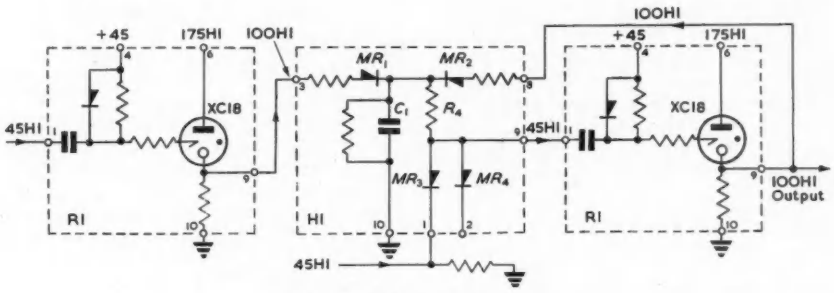


Fig. 12. Hold on element H1

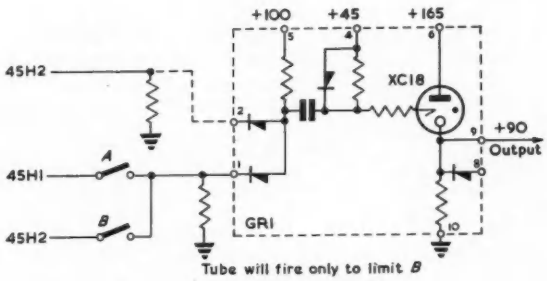


Fig. 13. Temporary memory GR1

AND matrix may be permanently connected to 45H2. Under these circumstances, the matrix will fire the tube only when 45H2 signals appear at terminal 1.

MATRIX ELEMENTS

Considerable use is made throughout the equipment of simple rectifier matrices connected so as to perform the logical operations of AND and OR. Two representative circuits are illustrated in Fig. 14.

The AND/OR element SM2, Fig. 14(a), is used to accept 45H1 (or H2) signals from limit switches and will deliver an output at terminal 9 only if similarly-phased signals are present at all of the terminals 1, 2 and 3. An output at terminal 8 will occur if a signal, of any phase, occurs at any one of the inputs.

Element CM5, Fig. 14(b), is used chiefly with the outputs of RC4 circuits. It is a simple AND configuration and will deliver an output only if similarly-phased signals are fed to all its inputs.

TIMERS

There is relatively little need in transfer machine control for timers but the unit T1 is available when required.

The circuit is illustrated in Fig. 15, and with no input to terminal 1, the voltage across capacitor C_1 is but a few volts above earth. When +100 is applied to terminal 1, however, the rectifier MR_1 cuts-off and C_1 commences to charge towards +165 at a rate determined by the product R_1C_1. As the voltage reaches the trigger-cathode striking potential, the XC23 conducts and the relay is energized. It will not release until the +100 input is removed.

The Complete System

Having described briefly the major circuit elements that comprise the ACCESS system, it is now possible to show how they may be combined together to effect control of a transfer machine. Only a representative selection of circuits will be described, however, since to attempt to cover the complete control would take far more space than is available here and, in any event, would be outside the strict scope of this article.

CLAMP/UNCLAMP CIRCUIT

This is a fundamental circuit in any transfer machine and serves to check that:

(a) All components are rigidly clamped in position prior to, and during machining

(b) All components are unclamped and free to move prior to transfer.

Each station of the machine is thus equipped with two limit switches. One of these is actuated when the clamping mechanism moves the component into its 'clamped' position, the other when the component is released. Signals from each pair are then fed down the machine to the Group Control where they act upon the circuit shown in Fig. 16.

Here it will be seen that the clamp and unclamp limits are fed from the two common supply lines 45H1 and 45H2. each pair signalling the Group Control via a single conductor. Within the control, these signals are applied to three-input AND matrices, type SM1 and also to pairs of neon indicators whose other electrodes are returned to −45H1 and −45H2. These neons form part of a plan-position display board and if it is assumed that, say, all the CLAMP limits are closed, then it will be realized from the waveforms involved that only those neons that are returned to −45H2 will be fired. Similarly, when all the UNCLAMP limits are closed and 45H1 signals are being transmitted. then only across the UNCLAMP indicators is there developed 90V peak-to-peak, which is sufficient to strike them. During this time, the CLAMP indicators have never more than 45V across them at any instant in the cycle and, consequently, remain extinguished.

Returning to the AND matrices referred to earlier, it will be seen that their terminal 9 outputs are commoned together and applied to two R1 elements, one in the UNCLAMP circuit, the other in the CLAMP circuit. By virtue of its 175H2 anode supply, the R1 in the CLAMP circuit can fire only to a 45H2 input and, hence, will do so when all CLAMP limits are closed and a 45H2 output is produced by the SM1 elements. The 100H2 output of the R1 element now passes to an RR1 element, where as already explained, it causes relay *CL* to be energized. This relay serves to apply power to the machine tool control panels only while the components are clamped and so avoids any possible accidental machining in the unclamped condition.

Three independent signals indicating that the machine is clamped are also required for use in the sequence circuits and as will be apparent later, these must be of phase H1. Therefore, in addition to feeding the RR1 element the 100H2 output of the R1 unit is applied to a PC1 circuit

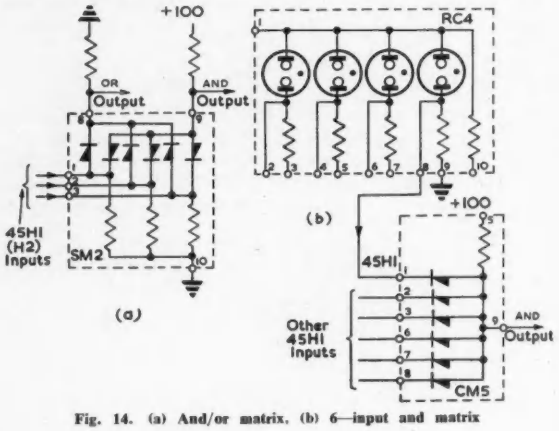


Fig. 14. (a) And/or matrix, (b) 6—input and matrix

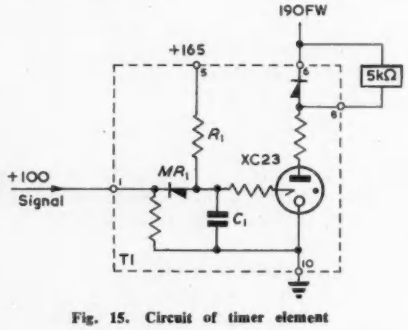


Fig. 15. Circuit of timer element

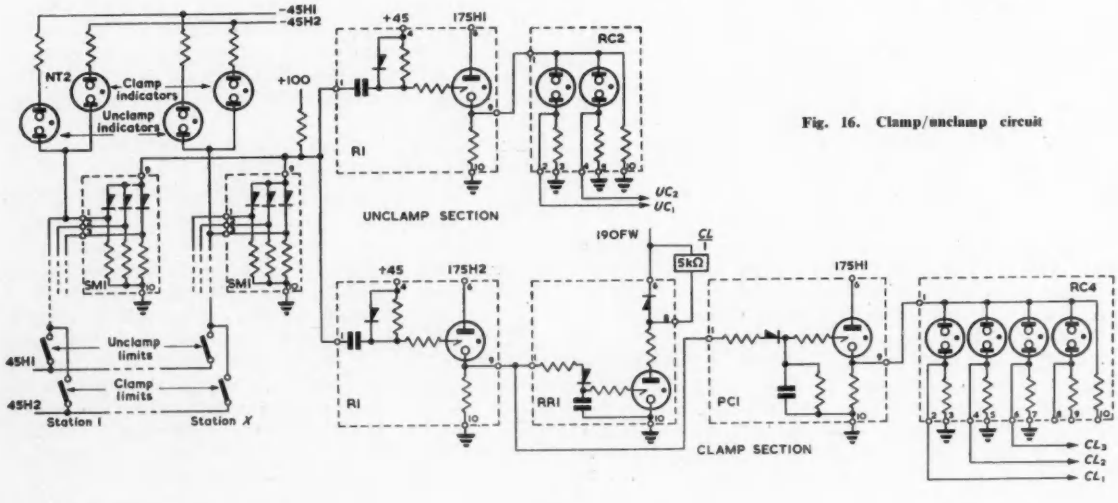


Fig. 16. Clamp/unclamp circuit

where it is converted to 100H1. This is then fed to the RC4 element and, as shown, the three 45H1 signals, CL_1, CL_2 and CL_3, are produced at terminals 2, 4 and 6.

Turning now to the UNCLAMP section of this circuit, it will be obvious that with a 175H1 anode supply, the tube of the R1 element can fire only to a 45H1 input. This will occur when all inputs of the SM1 matrices are receiving 45H1 signals and, hence, is indicative of the fact that all UNCLAMP limits are closed.

Only two signals signifying the unclamped condition are required later in the sequence circuits and these are derived from an RC2 element as illustrated.

It may be argued that to check that all the stations are clamped or unclamped, the simplest method is merely to connect all the appropriate limits in series. Experience has shown, however, that even when suitable indication is provided, the location of faulty limits in such a system can be very time-consuming and often reminiscent of locating burnt-out lamps in Christmas tree lights.

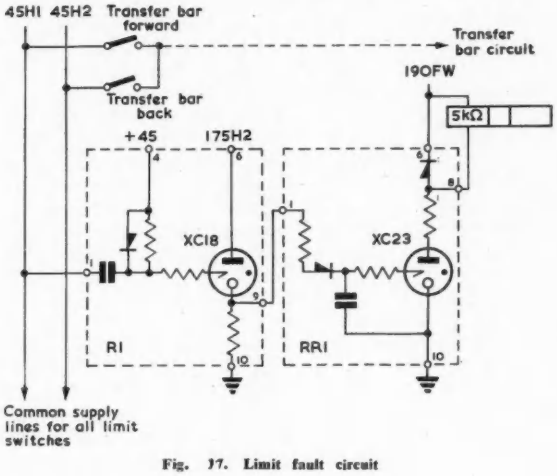


Fig. 17. Limit fault circuit

Limit Fault Circuit

One of the several ways in which this static control has improved upon previous systems is that, by a very simple circuit, it is able to detect the failure of practically every limit switch and stop the machine before any possible damage can occur.

In Fig. 17, two limit switches are shown transmitting either a 45H1 or 45H2 signal to the Group Control when the transfer bar of the machine is either fully forward or fully back respectively. The 45H1 and 45H2 supply lines are common to all limits on the machine.

It can probably be well imagined what would happen to a machine if, when operating automatically, the TRANSFER BAR FORWARD limit stuck closed and indicated to the sequence control that the bar was fully forward when, in fact, it was not. This condition, however, can be detected before damage occurs, because, if it is assumed that the bar goes forward normally, operates the FORWARD switch and returns leaving the switch stuck closed then, at the instant the bar re-operates the BACK limit switch, the 45H1 and 45H2 supplies will be connected together and become a full-wave supply, 45FW.

In the LIMIT FAULT circuit illustrated, the XC18 tube of the R1 element does not normally conduct since its anode is fed from 175H2 while its input is permanently connected to the 45H1 supply line. When, however, the 45H1 line becomes 45FW, as just outlined, then this tube does fire and its output, via the RR1 circuit, energizes one side of a mechanically-held two-position relay.

Operation of this relay trips out the main breaker and thus the damage that would occur if the bar went forward again is avoided.

Sequence Circuit

This, in effect, is the main circuit of the Group Control. It initiates all the various machine movements in the correct order, checking prior to each step that all the conditions for safety are satisfied. On the machine in question, there are five major steps in a cycle of operation and, in Table 2, these are given together with the conditions involved.

From Fig. 18, it can be seen that the circuit begins with five AND matrices having an appropriate number of inputs. Each matrix feeds an R1 element which, in turn, fires a common RR2 element so as to drive a uniselector one step forward. At each step, bank 2 of the uniselector energizes appropriate relays which then switch either pneumatic or hydraulic solenoid-operated valves.

The input signals to each of the five AND matrices are marked with the abbreviated circuit notation set out in Table 2. These signals are all 45H1 and emanate from diode elements such as the RC2 and RC4 shown in the CLAMP/UNCLAMP circuit, Fig. 16. Thus, for example, the input UC_1 on the TRANSFER matrix represents either a 45H1 signal when the machine is unclamped or, when the machine is not unclamped, a resistance-to-earth condition.

Assuming, then, that the machine is just unclamping and that all the other conditions necessary for TRANSFER are satisfied, 45H1 signals will be present at all the used inputs of the TRANSFER matrix with the exception of UC_1. At the

TABLE 2

Sequence of operations of transfer machine

SEQUENCE STEP	OPERATION	CONDITIONS TO BE SATISFIED	SIGNAL NOTATION
1.	TRANSFER	All stations unclamped	UC_1
		All unit heads back, clear of components	TL_2
		Unload station vacant	USV_1
		Unload roller track vacant	UTV_1
		Component available for loading	CA_1
2.	CLAMP ALL COMPONENTS	Transfer bar forward	TBF_1
		All unit heads back, clear of components	TL_3
		Load and unload bars back	$LUBB_1$
3.	LOAD AND UNLOAD BARS FORWARD	All components clamped in position	CL_1
		Load station vacant	LSV_1
	AND START UNIT HEADS	All heads back, clear of components	TL_4
		All components clamped	CL_2
4.	LOAD, UNLOAD AND TRANSFER BARS BACK	Load and unload bars forward	$LUBF_1$
		All components clamped	CL_3
5.	UNCLAMP ALL COMPONENTS	Transfer bar back	TBB_1
		Load and unload bars back	$LUBB_2$
		Load station full	LSF_1
		All heads back, clear of components	TL_1
		All heads have machined to depth	BL_1

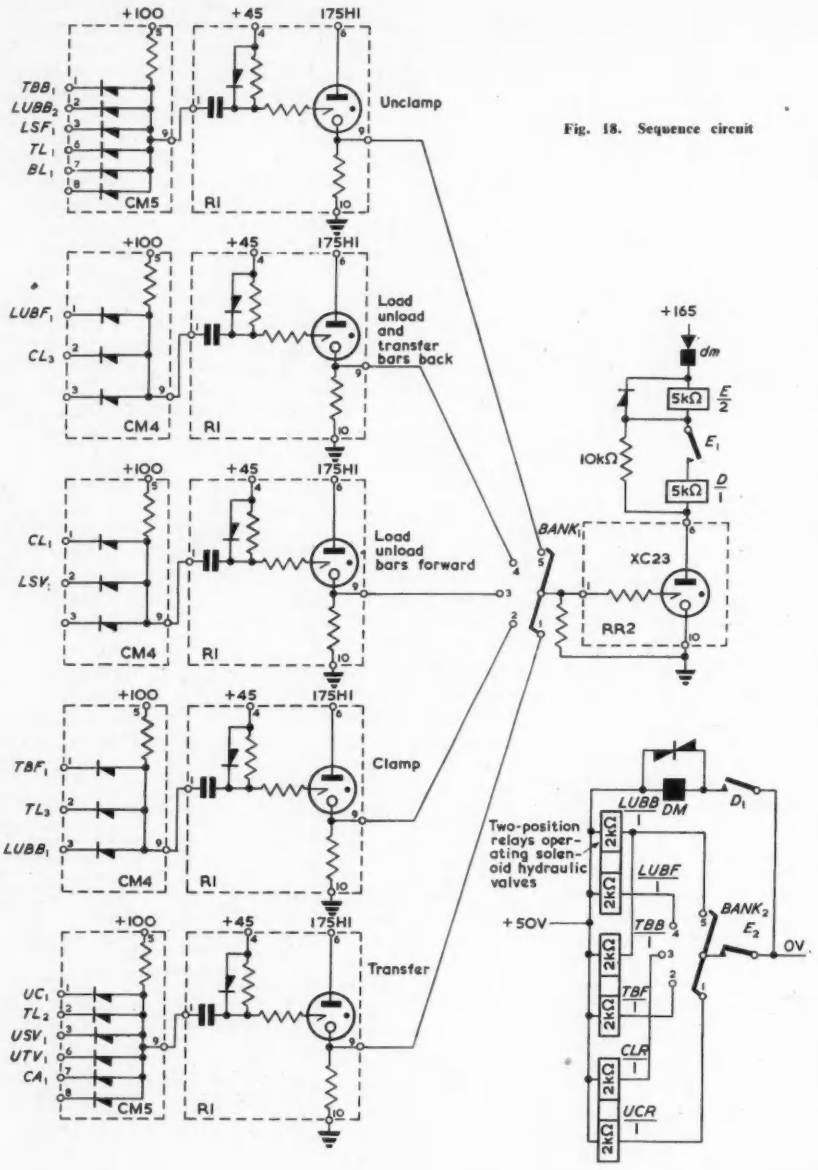


Fig. 18. Sequence circuit

instant the machine completes unclamping, however, 45H1 will appear at UC_1, the R1 element will fire and a 100H1 signal will be fed through bank 1 of the uniselector to fire the RR2 element. This XC23 tube now conducts to +165 via the uniselector interrupter contacts *dm*, the relay *E* and the 10kΩ resistor in shunt with contact E_1 and relay *D*. Relay *E* thus energizes and at contact E_2 interrupts the 50V supply from bank 2 to the sequence relays prior to stepping. Simultaneously, contact E_1 switches relay *D* into the XC23 anode circuit and contact D_1 subsequently energizes the drive magnet *DM* of the uniselector, which is of the forward-acting type. This now steps forward and as the wiper leaves contact 1 of bank 1, the 100H1 signal is disconnected from terminal 1 of the RR2 unit. The tube continues to conduct, however, until the uniselector completes its step, when the interrupter contacts *dm* open and break the d.c. supply. Both relays now release, *E* being slow due to the shunt rectifier, and at contact E_2, the 50V supply is restored to bank 2 where, via contact 2, it energizes the TRANSFER BAR FORWARD relay, *TBF*.

At the completion of the transfer movement, the TBF_1 signal will appear at the CLAMP matrix. If both the TL_3 and $LUBB_1$ signals are also present. the associated R1 tube will fire and the uniselector will make yet another step forward. This time, bank 2 will energize relay *CLR* and the machine will clamp up.

Thus it will be apparent that, provided all the 45H1 interlock signals are present at the relevant times, the sequence circuit will continue stepping, energizing the appropriate solenoids to give an automatic cycle. Manual facilities whereby each step can be controlled individually and, in some cases, be performed out of sequence, are also included but their circuit arrangements are omitted for clarity.

Conclusion

Although it was not practicable in an article such as this, to describe the entire system, it is hoped, nevertheless, that the circuits selected have presented a reasonable picture of the way in which ACCESS is applied.

Of the nine transfer machines so far equipped, the first was completed in December 1957 and has now been in continuous use, day and night, for some eighteen months. During this period the ACCESS Group Control has needed only 8½ hours maintenance and the replacement of two triodes and four diode indicators that failed very early in the life of the equipment.

It may be of interest in conclusion to explain why cold-cathode tubes were chosen as the basis of the system. Unlike both magnetic amplifiers and transistors, this type of tube possesses the enviable property of self-indication. To the maintenance man who has to keep an expensive machine running, this is of inestimable value and enables him to trace faults quickly and with the very minimum of test gear.

Acknowledgment

The author would like to thank the Directors of The Austin Motor Co. Ltd for permission to publish this article and to acknowledge the encouragement and advice given by Mr. F. W. Highfield who has since retired from the position of Superintendent of the Electronics Department.

A Vectorscope Unit

By K. G. Freeman*, B.Sc.

A vectorscope unit is described which provides a vectorial display of NTSC-type chrominance signals. Of high sensitivity, it incorporates a number of features, including means for continuously checking gain and quadrature adjustments. The instrument permits rapid assessment of chrominance signal phase and amplitude characteristics—which are of particular importance in direct-decoding operation of single gun colour television tubes.

(Voir page 706 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 711)

IN the NTSC colour television system the chrominance information is carried by a sub-carrier which lies in the high-frequency region of the video spectrum and is modulated in quadrature by the so-called *I* and *Q* colour difference signals. In addition a reference phase is provided by a burst of unmodulated sub-carrier at a fixed phase with respect to the quadrature modulation axes. Thus, any chrominance signal of given hue and saturation is represented by a phasor of appropriate phase and amplitude with respect to the reference phasor. Fig. 1(a) shows a single line of a typical NTSC colour bar composite video signal and Fig. 1(b) the corresponding chrominance signal phasor diagram.

It will be evident that if such a signal is synchronously detected along two axes in quadrature and the outputs from the detectors applied to the *X* and *Y* plates of an oscilloscope tube the display on the tube will be similar to the phasor diagram of Fig. 1(b). This is the basic principle of the vectorscope in which the arrangement of synchronous detectors is virtually identical with that in the low-level decoder used in early three-gun tube receivers. For a colour bar signal the vectorscope display will consist of a number of bright spots whose angular position and distance from the centre correspond to the phase and amplitude of the sub-carrier signal forming the bar pattern, joined by faint lines corresponding to the transitions between successive colours. For a normal colour picture, of course, the display will consist of a rather complicated 'fuzz', so that it is usual to employ the colour-bar signal to assess the chrominance signal characteristics.

The vectorscope display of the observed colour-bar chrominance signal may differ from the NTSC standard for several reasons, such as incorrect encoding, and phase distortion in the transmitter and the receiver i.f. amplifier etc. However, this form of display is also of considerable value in the study of direct-decoding circuits for single-gun colour tubes.

In order to improve the quality of reproduction of colour pictures with these tubes various forms of signal processing may be employed, which have the effect of modifying the phases and amplitudes of the chrominance phasors. In such circumstances, a vectorscope provides the easiest means of examining the form of the modified chrominance signal.

Although various types of vectorscopes have been described in the literature[1-6], the design of the one described in this article represents a somewhat different approach, and complete circuit details are given.

Basic Design Considerations

The vectorscope was intended primarily as a laboratory tool, but as it seemed possible that there might ultimately be a more general demand for such an instrument, for example, in the servicing field, it was decided that it should be as simple as possible consistent with the availability of adequate controls. The vectorscope unit was therefore designed to directly drive the *X* and *Y* deflexion plates of the Mullard oscilloscope tube type DG 13-2, as used in the Mullard type L101 dual trace oscilloscope. The requisite

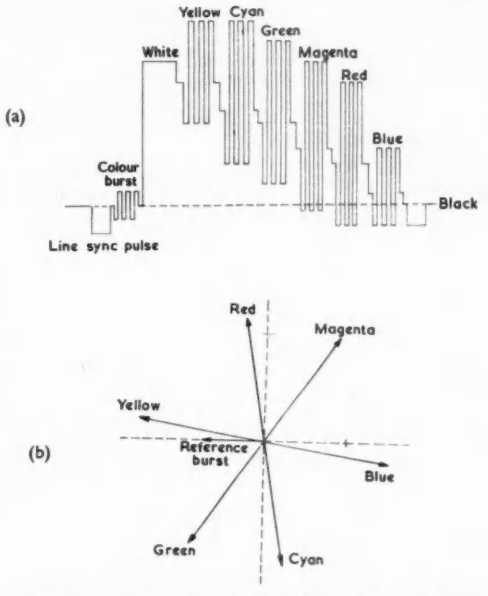


Fig. 1. (a) Single line of a typical NTSC colour bar composite video signal (b) Phasor diagram of chrominance signal of Fig. 1(a) colour bar pattern

gain and shift controls are incorporated in the driving amplifiers following the synchronous detectors.

A further simplification is possible, at the expense of some slight sacrifice of performance, by making use of the *X* and *Y* amplifiers of the L101 oscilloscope. In this case the long-tailed pair output stages can be dispensed with—although some means of gain control will still be required.

For operation of the synchronous detectors a source of reference frequency (sub-carrier) is required which is phase-locked to the colour 'burst'. In more elaborate vectorscopes this is derived from the signal under investigation by means of a burst gate and a crystal oscillator which is locked by an automatic phase-control (a.p.c.) loop. This was felt to be an unnecessary complication as a source of locked sub-carrier is usually available in practice in either the encoder or decoder.

For the vector display to have any meaning it is essential that the synchronous detectors operate exactly in

* *Mullard Ltd.*

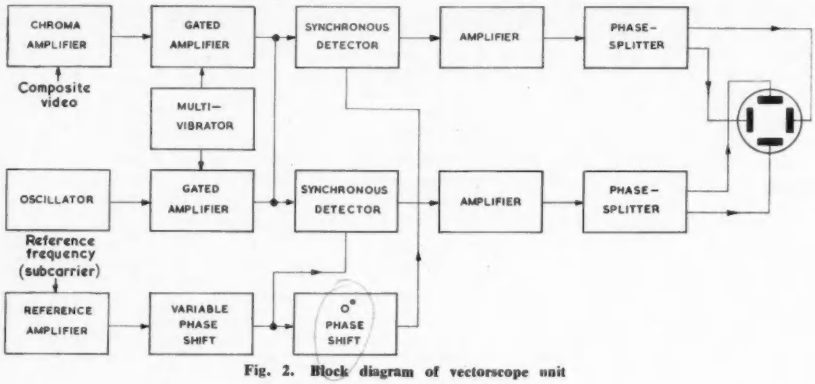
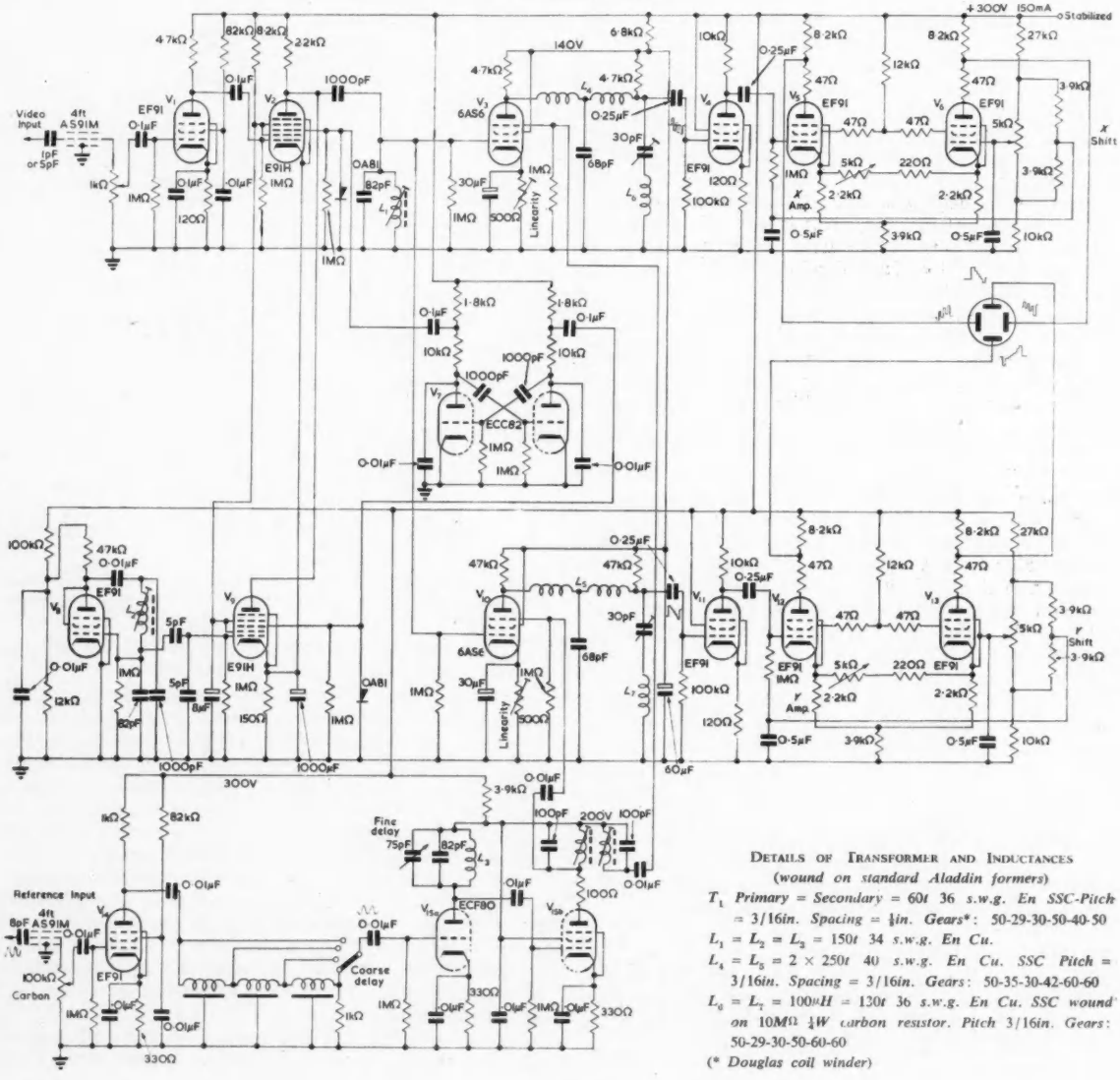


Fig. 2. Block diagram of vectorscope unit

Fig. 3. Vectorscope unit translator (*all resistor 1/4W except where otherwise stipulated*)



DETAILS OF TRANSFORMER AND INDUCTANCES
(*wound on standard Aladdin formers*)

T_1 *Primary = Secondary = 60t 36 s.w.g. En SSC-Pitch = 3/16in. Spacing = 1/4in. Gears*: 50-29-30-50-40-50*

$L_1 = L_2 = L_3 = 150t$ *34 s.w.g. En Cu.*

$L_4 = L_5 = 2 \times 250t$ *40 s.w.g. En Cu. SSC Pitch = 3/16in. Spacing = 3/16in. Gears: 50-35-30-42-60-60*

$L_6 = L_7 = 100\mu H = 120t$ *36 s.w.g. En Cu. SSC wound on 10MΩ 1/4W carbon resistor. Pitch 3/16in. Gears: 50-29-30-50-60-60*

(* *Douglas coil winder*)

quadrature and that the overall X and Y channel gains be equal. Provision for ensuring this state of affairs is therefore necessary, and in this unit it is done as follows. A stable oscillator free runs at a frequency near to sub-carrier and this is gated alternately with the chrominance signal being examined. This produces on the screen of the tube an elliptical or circular trace superimposed upon the vectorial display due to the chrominance signal. Under correct gain and phase conditions the trace is a circle and it is a simple matter to make the appropriate adjustments to obtain such a circular trace, which is always present, thus providing a continuous check of the operating conditions.

Finally, since the phase of the chrominance signal and its reference burst varies through the circuit under examination the trace on the screen may have any angular orientation. As it is desirable to be able to have a fixed orientation of trace (e.g. with the colour burst phasor in the $-x$ direction) for comparison against an engraved scale, it is therefore necessary to have provision for changing the phase of synchronous detection. This is most easily achieved by having a variable delay in the reference frequency amplifier with a range of 0° to 360° of one cycle of sub-carrier. Again this is a feature included for convenience in the laboratory and, in general, could be omitted if a rotating graticule is used.

Fig. 2 shows the block diagram of the vectorscope unit embodying these principles.

The gated output appearing at the commoned anodes of V_2 and V_9 is limited to a bandwidth of about 1Mc/s centred on the sub-carrier frequency by the damped tuned anode circuit, which ensures that only chrominance video information is passed to the synchronous detectors. Since the vectorscope is used only on colour-bar test signals and the edges corresponding to the fast chrominance transitions are not of prime importance, the damped single-tuned circuit is adequate. For convenience 6AS6 short-suppressor-grid-base pentodes are used as the synchronous detectors and with some adjustment of operating conditions give a sufficiently linear performance at the low signal levels involved. E91H dual-control valves were tried but found unsatisfactory. Reference frequency (sub-carrier) for the operation of the synchronous detectors is obtained through a low-capacitance probe, amplified by V_{14} and applied to a terminated length of 1kΩ delay cable (delay ~70mμsec/ft)

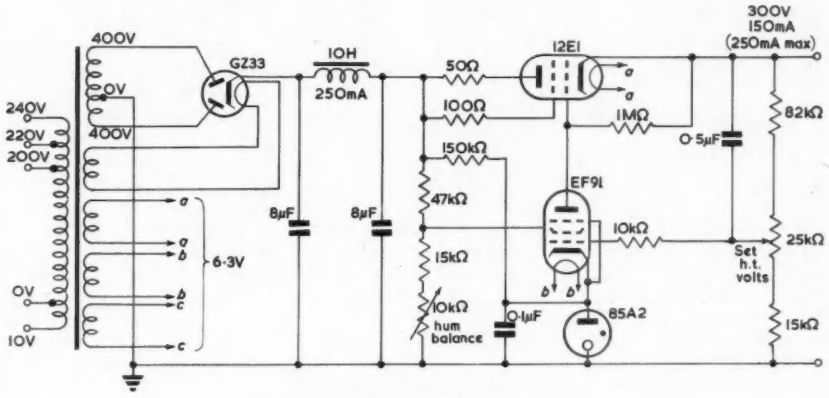


Fig. 4. Vectorscope unit power supply

Detailed Description of Vectorscope Unit Translator

Fig. 3 shows the complete circuit diagram of the vectorscope unit (less its power supply) which will now be described in more detail. The composite video under investigation is applied via a 1pF probe to the amplifier V_1. Its low capacitance ensures that the signal is not significantly modified by the probe, and it also has the additional advantage of removing most of the unwanted lower-frequency luminance component. The output from V_1 is then applied to the first grid of V_2 (E91H) which is a dual-control valve. On the first grid of a second E91H, V_9, is applied the output from the oscillator V_8.

This oscillator is adjusted to free-run at a frequency within some 10 to 20kc/s of sub-carrier, and is operated from an h.t. line of only about 30V to maintain stability and keep radiation to a minimum. Even so, the unit is so sensitive that additional attenuation is necessary to give the desired low-level of local oscillator voltage on the grid of V_9.

The two valves, V_2 and V_9 are operated alternately for equal periods of time by driving the second control grids with the output from a symmetrical multivibrator V_7 which has a frequency of about 300c/s. The multivibrator operation is conventional but 0·01μF capacitors are connected from the triode anodes to earth to slow the multivibrator waveform edges, and give a gated output from V_2 and V_9 devoid of overshoots. D.C. restoration of the multivibrator waveform enables the use of a minimum amplitude and better operating conditions for the E91H's.

which is tapped so that delays of 0°, 90°, 180° and 270° of one sub-carrier cycle are obtainable. Fine delay is obtained by detuning of the anode circuit of V_{15} triode. The output is fed to the pentode of V_{15} which drives a double-tuned transformer T_1. By suitably tuning the primary and secondary circuits, sub-carrier outputs with the desired quadrature relationship for operation of the synchronous detectors are readily obtained. The overall sensitivity of the reference amplifier is such that correct synchronous detection—independent of reference amplitude—is obtained for a reference voltage input to the 8pF probe of more than approximately 0·5V r.m.s. As in receiver-decoder circuits the synchronous detectors are followed by low-pass filters, but in this case they are identical, with a cut-off frequency of about ½Mc/s. To further attenuate the reference frequency component in the output, series-tuned circuits resonant at sub-carrier are connected between earth and the low-pass filter outputs.

The outputs from the filters, after amplification by V_4 and V_{11}, are applied to the long-tailed pair output stages V_5V_6, $V_{12}V_{13}$. These are of convential design, with gain and shift controls and provide sufficient output to drive directly the X and Y plates of Mullard L101 oscilloscope tube type DG13-2 via a yard or so of four-core unscreened lead.

The overall sensitivity using the 1pF probe is such that a full-size trace on this oscilloscope tube is obtained for a chrominance signal amplitude of about 0·3V r.m.s. For rather smaller chrominance signals a 5pF probe should be adequate.

The Vectorscope Unit Power Supply and Layout Considerations

It is clear that an instrument of this sensitivity needs a well-stabilized and hum-free power supply. Fig. 4 shows a suitable power supply for the unit described, which has a hum level of only about 2mV and gives a sufficiently hum-free trace.

The greatest difficulty encountered in the design and construction of this vectorscope unit is that radiation between various stages of the ' translator ' leads to distortion of the trace due to the presence of spurious sub-carrier at the input to the synchronous detectors. The greatest care in the design of the chassis layout is therefore recommended, particular attention being paid to ensuring that the reference and chrominance amplifiers and the free-running oscillator are all adequately screened from one another.

Conclusions

A vectorscope unit for laboratory work which is likely to be of general use has been described. Of adequate stability and high sensitivity it enables rapid checks to be made on NTSC type encoders, decoders and signal translators.

Acknowledgments

The author wishes to thank the Director of Mullard Research Laboratories and the Directors of Mullard Limited for permission to publish this article.

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A Ship Hydrodynamics Laboratory

A new Ship Hydrodynamics Laboratory of the Department of Scientific and Industrial Research was opened officially by H.R.H. the Duke of Edinburgh at Feltham, Middlesex, on 19 October.

The new Laboratory, which will be part of the Ship Division of the National Physical Laboratory, has three main facilities:

(1) A large towing tank 1,300ft long, 48ft wide and 25ft deep with an associated wavemaker.
(2) A large water tunnel with a measuring section of 44in diameter.
(3) A sea-keeping and manœuvring basin 100ft square with a water depth of 8ft.

In addition, there are workshops for the making of model hulls and propellers, a vibration laboratory and instrument laboratories for development, testing and calibration purposes.

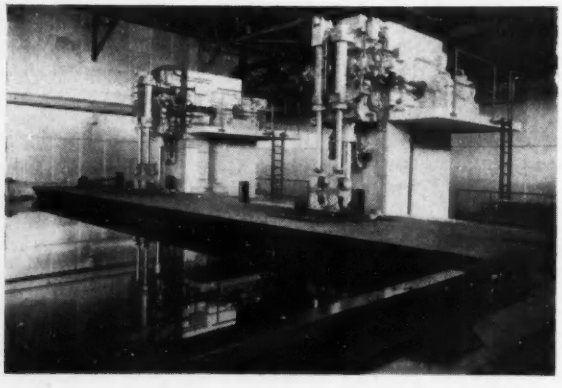
These new and up-to-date facilities for hydrodynamic research which are claimed to be the most advanced in Europe are designed to reproduce in the Laboratory more nearly realistic sea conditions than has been possible in the past. The main aim of the research programme will be to build up basic knowledge for the design of ships that can maintain high speeds in rough seas without danger and with a minimum of discomfort.

The large towing tank will enable much bigger models to be used than at Teddington and it will also allow studies to be made on submerged models of submarine cargo ships and tankers when these become necessary.

The wavemaker in the towing tank consists of a large wedge-shaped plunger weighing 20 tons, installed at the remote end of the tank.

The plunger is set in motion by hydraulic cylinders and is controlled by an electronic-hydraulic servo mechanism which continuously monitors the position of the plunger relative to a correct position determined by a control setting and applies a correcting action if any error exists.

The wavemaker installation at the remote end of the large towing tank



The electronic equipment for the system was supplied by Associated Electrical Industries Ltd, Electronic Apparatus Division, Leicester.

The circuits can be divided into two groups:

(a) Circuits required to produce signals which direct the movement of the wedge in accordance with specified requirements.
(b) Circuits which constrain the wedge to follow the director signals to the required degree of accuracy.

The wedge produces waves having amplitudes and frequencies which are infinitely variable between set limits, the amplitude limits being 0 to 1·5ft, the frequency being 1 cycle of 2·8sec to 1 cycle of 0·95sec. The frequency is achieved by driving a Selsyn through a precision gearbox from a motor controlled by a high-accuracy speed regulator. The output from the Selsyn excites an inductive potentiometer which provides a control of the amplitude. The setting of the potentiometer is remotely controlled from a desk by means of an accurate position-control sub-servo.

The controls operate through sub-servos for the purposes of convenience of control and prevention of excessive acceleration and velocity on the plunger. An auxiliary function of the sub-servos is to establish a sequence of operations when starting and finishing tests.

Controlling the movement of the wedge is the most difficult problem associated with the wavemaker. Because of the great length and mass of the wedge, it was considered impracticable to drive it from a single actuator, and in consequence, the ends of the wedges are driven by ram systems which are completely separate from one another. Thus, the servos associated with each end of the wedge must be carefully matched This is achieved by a comprehensive scheme of local feedback loops, so designed that the hydraulic elements within the loops have their individual characteristics largely overridden.

The feedback loops are excited from displacement pick-off devices measuring the movement of hydraulic valves, and from tacho-generators and Selsyns measuring the position and speed of the main pump's wash and the main ram.

Tests on hydrofoil sections under controlled pressures up to six atmospheres can now be made in the new 44in diameter water tunnel. The tunnel will also permit tests on propeller models up to 24in diameter.

The sea-keeping tank is designed so that experiments can be carried out on a model in waves at varying angles to its course and in irregular and confused seas. Models will be free running and remotely controlled and considerable thought has been given to the design of the control and recording equipment which has to be kept as light and compact as possible. Instrument data will be either recorded in the model or telemetered ashore.

Fitting up and trimming of models which may be up to 10ft in length will be carried out in the manœuvring tank.

Compound Semiconductors

By D. A. Wright*, D.Sc., M.Sc., F.Inst.P.

This article first discusses the more important parameters governing the behaviour of semiconductors. These considerations are then applied to the various types of semiconducting compound which have so far been studied, and values of the mean parameters are quoted. The usefulness of the materials for different applications is discussed in the light of these figures. In each type of compound, definite trends are observed in the relationship between the semiconducting parameters and other physical properties. These trends are described and their interpretation is indicated. The parameters which are important for thermoelectric applications are mentioned briefly, together with the bearing of the earlier discussion on the choice of materials for these applications.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 711)

RESEARCH and development on semiconductors have been concentrated during the last ten years primarily on germanium and silicon, because of their application to rectifiers and transistors. However, at the same time interest in semiconducting compounds has been maintained and has increased recently. Several semiconducting oxides and sulphides have been known for many years, e.g., zinc oxide, copper oxide and lead sulphide. Since 1950 numerous other semiconducting compounds have been studied, in particular binary compounds between a metal and either selenium, tellurium, phosphorus, arsenic or antimony. The objectives in this work have been twofold; firstly to try to find materials which might be superior to germanium and silicon for making pn junction diodes and triodes; secondly, to find new effects which might ultimately have commercial applications or new materials in which known effects might have much greater magnitude, and therefore usefulness, than in materials known at present.

Probably the most thorough investigation has been made of the compounds between Group III_B elements, e.g., aluminium, gallium or indium with Group V_B elements, e.g. phosphorus, arsenic or antimony; these compounds have similar crystal structure to that of germanium, and are not too difficult to prepare with a high degree of purity and in stoichiometric proportions.

Another class fairly extensively investigated is that formed by compounds between Group VI_B elements, e.g. sulphur, selenium or tellurium with Group II_B metals, e.g. zinc, cadmium or mercury, or with lead, which is related to these metals. These are more difficult to make stoichiometric, while some of them can exist either in a hexagonal crystal structure or in cubic form related to that of germanium. The transition between these forms as a crystal grows often leads to 'stacking disorder' in regions where locally the atoms form patterns intermediate between those characteristic of the two stable structures. These imperfect regions may have a considerable effect on the properties of the crystals, as discussed below.

The elements germanium, silicon and diamond have a crystal structure in which each atom has four nearest neighbours and is bonded to each of these with two electrons symmetrically placed between the atoms. This is a 'covalent' bond. In many of the compounds referred to above the structure is similar, but the electrons in the bond are not situated symmetrically so that there is a small effective charge on each of the atoms. Compared with purely covalent bonds, these partial ionic charges increase the extent to which electrons are scattered when moving in the crystal. The consequences of this increased scattering are also discussed below. In the more extreme cases of compounds between Group I and Group VII elements, e.g., sodium chloride or silver bromide, the asymmetry is much greater. The former compound consists of positively charged sodium ions and negatively charged chlorine ions, the bond being ionic and not covalent. These compounds are insulators at ordinary temperatures, and on heating develop ionic rather than electronic conductivity.

There are numerous other types of binary compound with somewhat more complex structures which are now known to be electronic semiconductors. Some such compounds and their properties are indicated in Tables 5, 6 and 7. There are in addition many possible types of ternary compound semiconductor, some of which are being investigated at the present time. Many of these are related structurally with one or another of the series of binary compounds already described. Because of this some rough prediction of their properties can be made, and it is possible to select out of a very large number of possibilities those compounds which are most likely to be worth studying. Those investigated up to the present are difficult to prepare as single crystals, and to obtain in stoichiometric proportions.

Most of the compounds mentioned so far fit broadly into the theoretical approach to semiconductor physics built up in recent years, based on the 'band theory' of solids. When this is so, the compounds may be described as 'normal' semiconductors. However, there are other compounds which have semiconducting properties, but to which the band theory does not apply, and some of these may become of increasing technical importance. The series In_2Te_3, Ga_2Se_3, etc., fall into this class, as do the refractory oxides of nickel, iron and other transition metals containing appropriate impurities. These have not been very fully studied so far; the main differences between them and normal semiconductors are discussed below.

Electrical Conductivity

The flow of electric current in a semiconductor depends on n, the density of free carriers of electric charge, and on μ, the 'mobility' of these charge carriers. The mobility is the drift velocity acquired by the carriers in the crystal in unit field, so that the conductivity σ has the value $ne\mu$, where e is the charge on the electron. The carriers can be either electrons or 'holes', according to the type of semiconductor, or both may be present at the same time, in which case the density and mobility of both must be taken into account.

In a pure crystal, having stoichiometric proportions of its constituents if it is a compound, the density of electrons, n_e, is equal to that of holes, n_h. The density depends on the

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'effective masses' of the electrons and holes, and varies exponentially with temperature and with the forbidden energy gap of the crystal. This is the 'intrinsic' case. The variation with temperature is illustrated in Fig. 1. When certain types of impurity or of lattice defect are present, at a density n_o, they may provide localized donor or acceptor levels within the forbidden gap. When these are shallow, at a small energy separation from the nearer band edge, the levels are all ionized at quite low temperatures, and the density of free carriers is then equal to n_o. The carriers concerned are electrons if the levels are 'donor' levels near the edge of the conduction band, holes if they are 'acceptor' levels near the edge of the valence band. As shown in Fig. 1, the carrier density is constant at the value n_o over a considerable temperature range, until ultimately as temperature rises the intrinsic carrier density becomes greater than n_o. Over the range where it is less, the semiconductor is 'extrinsic'. Semiconductors are normally used in the temperature range where the extrinsic

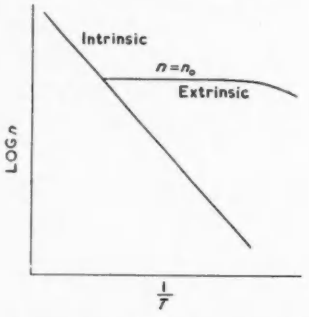

Fig. 1. Variation of carrier density n with absolute temperature t

carrier density has the constant value n_o, either electrons (n-type) or holes (p-type). The values of n_o required lie typically between 10^{14} and $10^{18}/cm^3$, according to the application. Whatever value is decided upon to meet the requirements of the device must be obtained quite accurately and reproducibly, so that the technology for making and controlling the semiconductor is correspondingly difficult.

If the energy gap for a semiconductor is QeV, the intrinsic carrier density is proportional to $\exp(-Q/2kT)$, where T is the absolute temperature and k is Boltzmann's constant. The temperature at which a semiconductor becomes intrinsic, i.e., at which the intrinsic carrier density becomes greater than n_o, depends on the value of n_o, but is clearly larger, the larger the value of Q. For values of n_o near 10^{16}, which are typical for many applications, InSb with a gap of 0·17eV becomes intrinsic at 20°C. Ge and Si respectively have gaps of 0·65 and 1·1eV and become intrinsic at 150°C and 300°C. For most applications therefore these materials can only be used below these temperatures.

Mobility

For most applications μ is required to be as large as possible, so that it is necessary to consider factors controlling its magnitude. It should be noted that in general it is not required to have large values of $\sigma = ne\mu$. The operation of semiconductor devices frequently depends on changes in the value of σ due to changes in n, and such changes are of greater significance if n and therefore σ are not initially too large. However, in transistors one needs a high μ in order to obtain a high diffusion constant $D = (kT/e)\mu$ and a high diffusion length $L = \sqrt{(D\tau)}$, where τ is the 'lifetime' discussed below. A detailed consideration of transistor action shows that the mobility of both types of carrier is important, and that there is a figure of merit for high frequency operation given by $\mu_e\mu_h/\epsilon^3$, where ϵ is the dielectric constant. μ_e is the mobility of the electron and μ_h that of the hole. Again, in applications of the Hall effect, a high open-circuit voltage is obtained provided n is small, but to obtain a useful power output μ must be large, in fact the power obtainable is proportional to μ^2. Photoconductivity depends in magnitude directly on μ as well as on the lifetime τ, while as will be discussed further below, thermoelectric refrigeration or generation requires, among other things, a high value of μ.

The mobility depends on the 'effective mass' of the charge carriers and on the details of the processes by which they are scattered when moving through the crystal. The concept of effective mass arises because the electron moving in the crystal, even in the absence of any collision processes, is in a region of electrostatic potential different from that in vacuum, so that its laws of motion are quite different. When its energy alters, part of the change in momentum is shared with the crystal lattice, so that the effective mass differs from that in vacuum, and is moreover a function of energy and of direction of motion in the crystal. Different methods of averaging are used to define effective mass parameters applicable to different types of process.

Solid-state theory is not yet developed sufficiently to make it possible to calculate and predict from the crystal structure what the details of the effective mass will be in any semiconductor. There is a certain amount of experimental information, but it is available in detail only for germanium, silicon and indium antimonide.

As regards the scattering processes, the electrons may be scattered by vibrations of the crystal lattice, by charged impurity atoms, or by uncharged impurities or defects in the crystal. The scattering by the lattice, leading to a mobility μ_L, may involve the 'acoustic mode', in which neighbouring atoms are displaced in the same direction, or 'polar modes', in which they are displaced in opposite directions. With covalent bonding the former dominate the scattering process, and lead to a lattice mobility which falls as temperature rises, varying as $T^{-3/2}$, as shown in Fig. 2. In crystals where there is some ionicity, the opposite charge on neighbouring ions results in considerable scattering by vibrations in the polar mode. This scattering is likely therefore to be greater than that produced by the acoustic mode. It leads to a lattice mobility which again falls as temperature rises, though the relation may be either more or less steep than $T^{-3/2}$. As the ionicity increases this scattering effect becomes larger, until with the alkali halides, e.g., sodium chloride referred to above, polar mode scattering causes very low mobility. When the ionicity is intermediate, the scattering is larger for a given effective mass than it would be for a covalent crystal, especially for low effective mass, thus even the very large mobilities for indium antimonide and indium arsenide (Table 2) are lower than they would be in a covalent crystal with electrons of similar effective mass. In the Group III-V compounds the atoms have an effective charge between 0·3 and 0·5 of the electronic charge due to the asymmetry of charge distribution between the atoms referred to earlier.

When impurities are present in the semiconductor, and the temperature is high enough to ionize them, there is an additional scattering process leading to a mobility μ_I which is proportional to $T^{3/2}$, and inversely proportional to the density of ionized impurity centres. Fig. 2 shows $\log \mu$ plotted against T, and indicates that at low temperature

the net value, given approximately by $1/\mu = 1/\mu_L + 1/\mu_I$, is determined by impurities, whereas at high temperature it is determined by lattice scattering. Curve A refers to a low impurity density, B to a higher one, both for acoustic mode lattice scattering. Scattering by uncharged impurities, stacking disorder and dislocations has an effect which is itself independent of temperature and which is in most cases only significant at low temperatures. In the absence of ionized impurities, neutral impurities or dislocations lead to the behaviour shown dotted at low temperatures instead of the increase characteristic of μ_L. It is clear that crystal imperfections and impurities must be avoided in order to obtain the mobility μ_L at the lower temperatures, and that with high defect densities the depression of μ below μ_L will be appreciable at room temperature. It is clear also that if in order to attain a required conductivity a

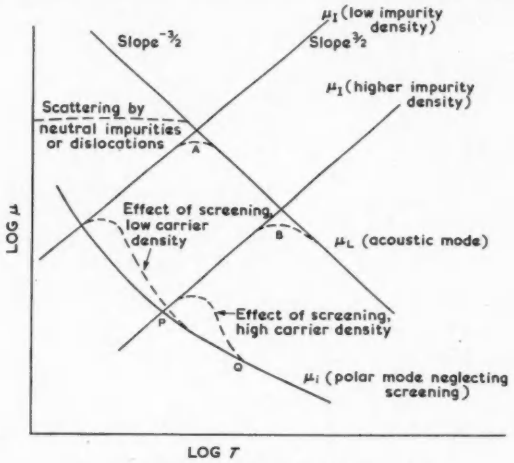

Fig. 2. Variation of mobility with temperature

relatively high value of n_o is required, this is likely to lower μ below μ_L. Ultimately σ may not continue to rise as n_o rises, because of the decrease in μ.

Exceptions to the general rule that mobility will fall as n_o rises may occur when the lattice scattering is due to polar rather than acoustic mode vibrations. Then, as the carrier density rises, the carriers 'screen' the interaction between any one electron and the dipoles produced by the vibrations. When this screening effect is appreciable, the value of μ_L will increase as n_o rises. This will be negligible at the higher temperatures, and will result in an increase in the net mobility for an intermediate temperature range, as shown between P and Q in Fig. 2.

With all 'normal' semiconductors, the mobility decreases as temperature rises in the high temperature range as in Fig. 2, whatever the details of the scattering mechanism. However, in the abnormal ones referred to at the end of the introduction, the electrons move by a 'hopping' process from one atom to another, so that energy is needed in order to free them. This results in an increase in mobility as temperature rises, though mobility at room temperature is usually very much less than in a normal semiconductor. It may be noted, however, that similar mechanisms may occur in normal semiconductors at low temperatures in the case of conductivity in an 'impurity band.'

Lifetime

If the electron and hole densities are perturbed from their thermal equilibrium values, the lifetime τ is the time-constant of the process of return to equilibrium after the stimulation ceases. This is important in photoconductivity and in pn junction devices where the operation of the device involves the injection across the junction of 'minority' carriers, i.e. of holes into an n-type semiconductor or vice versa. The device will not operate unless these minority 'live' long enough to reach another pn junction or a collecting electrode. The lifetime depends on the processes of recombination of electrons and holes, which are profoundly influenced by impurities, lattice defects and dislocations.

High Field Effects

It may be noted that the current does not necessarily increase linearly with voltage in a semiconductor. One departure from linearity arises if the electrons become 'hot', i.e., if they are accelerated by the field E until they are no longer in thermal equilibrium with the crystal lattice. When this occurs, above a critical field strength the mobility μ varies as $E^{-\frac{1}{2}}$, so that the current rises with field, but only as $E^{\frac{1}{2}}$. At still higher fields the current saturates. Another effect, which may be superposed on the first, is that electrons may acquire sufficient energy between collisions to free further electrons from the ions of the crystal when they collide with them. This leads to multiplication of the carrier density to a high value and a consequent large increase in current.

At low temperatures most of the electrons associated with impurities will be bound to the impurity atoms. The few free electrons can be accelerated in quite low fields until their energy is sufficient to ionize these impurities, so raising the free-carrier density near to its maximum extrinsic value n_o. Thus a considerable increase in current density can occur at quite low fields, e.g., at a few volts per centimetre in germanium at 4°K. Similar effects have been observed recently in indium antimonide and indium phosphide. New types of application are likely to result both from 'hot' electron processes and multiplication processes.

Classes of Semiconductor

The Elements

Germanium and silicon are the semiconductors most thoroughly investigated and most completely under control. Their properties are listed in Table 1. Donor levels in germanium, at a depth of the order 0·01eV, are fully ionized above 20°K. In silicon they are deeper and are fully ionized above about 90°K. The mobility in Ge is high enough to achieve transistor operation at high frequencies, up to 500Mc/s or more in pn junction devices with base widths of about 2μ. Lifetimes in Ge as high as 1msec can be obtained, though these are not necessary for high frequency applications. In silicon the mobility is lower, and for a given geometry the upper frequency limit is below that of germanium. If transistor behaviour is desired above 200°C, a higher gap is needed than that of silicon; for high frequencies this should ideally be combined with a mobility at the operating temperature comparable with that of germanium at room temperatures. This would however call for a material with a very high mobility at room temperature. in view of the fall of μ_L as T rises, discussed under 'Mobility'.

Silicon Carbide

There is a considerable electronegativity difference between silicon and carbon, so that the compound between them has a considerable degree of ionic bonding. The effective charge on the ions is about 0·9e. This leads to a mobility less than that resulting from covalent-bond lattice-

TABLE 1

	Atomic Weight M	Melting Point (°C)	Energy Gap Q (eV)	Debye Temperature θ (°K)	Dielectric Constant ε	Mobility: Electrons μ_e ($cm^2\ V^{-1}\ sec^{-1}$)	Mobility: Holes μ_h ($cm^2\ V^{-1}\ sec^{-1}$)	Ratio of Effective Mass to Free Electron Mass: Electrons m_e	Ratio of Effective Mass to Free Electron Mass: Holes m_h	Thermal Conductivity K_0 (W/cm °C)
Diamond	12·0	3500	5·2	1950		1800	1200	—	—	1·95
Si	28·1	1420	1·1	652	11·7	1300	500	0·26	0·4	1·13
Ge	72·6	940	0·65	362	15·7	3800	1800	0·12	0·2	0·63
Sn	118·7	—	0·08	215	—	2000	1000	—	—	—
					L.F. H.F.					
SiC	20·0	—	2·8	—	10 6·7	~100	~20	0·6	1·2	—

TABLE 2
III-V Compounds

	Atomic Weight M	Melting Point (°C)	Energy Gap Q (eV)	Debye Temperature θ (°K)	Dielectric Constant ε	Mobility: Electrons μ_e ($cm^2\ V^{-1}\ sec^{-1}$)	Mobility: Holes μ_h ($cm^2\ V^{-1}\ sec^{-1}$)	Ratio of Effective Mass to Free Electron Mass: Electrons m_e	Ratio of Effective Mass to Free Electron Mass: Holes m_h	Thermal Conductivity K_0 (W/cm °C)
BN	12·5	—	~5·0	—	—	—	—	—	—	—
BP	21·0	—	—	—	—	—	—	—	—	—
GaN	42·0	—	3·3	—	—	—	—	—	—	—
AlN	20·5	—	—	—	—	—	—	—	—	—
AlP	29·0	—	3·0	—	—	—	—	—	—	—
AlAs	51·0	—	2·2	—	—	—	—	—	—	—
AlSb	74·0	1060	1·65	—	8·4	1200	150	—	0·4	—
GaP	50·5	—	2·3	—	—	—	—	—	—	—
GaAs	72·5	1240	1·3	356	—	5000	200	0·04	—	—
GaSb	96·0	700	0·8	—	14·0	4000	1000	0·05	—	0·27
InP	73·0	1070	1·2	—	—	4000	200	0·04	—	—
InAs	95·0	940	0·45	—	—	30000	200	0·03	~0·3	0·3
InSb	118·0	523	0·2	205	16·0	80000	800	0·015	0·18	0·15

TABLE 3
II-VI Compounds

	Atomic Weight M	Melting Point (°C)	Energy Gap Q (eV)	Debye Temperature θ (°K)	Dielectric Constant ε: L.F.	Dielectric Constant ε: H.F.	Mobility: Electrons μ_e ($cm^2\ V^{-1}\ sec^{-1}$)	Mobility: Holes μ_h ($cm^2\ V^{-1}\ sec^{-1}$)	Ratio of Effective Mass to Free Electron Mass: Electrons m_e	Ratio of Effective Mass to Free Electron Mass: Holes m_h	Thermal Conductivity K_0 (W/cm°C)
ZnO	41·0	—	3·2	—	8·5	4·0	1000	—	0·07	—	—
CdO	64·0	—	2·2	415	—	5·8	100	—	—	—	—
ZnS	44·0	1850	3·6	—	—	—	—	—	—	—	—
ZnSe	72·0	1000	2·6	—	—	—	—	—	—	—	—
ZnTe	96·5	1240	2·1	—	—	—	—	—	0·2	—	—
CdS	72·0	1475	2·4	—	—	6·2	200	20	0·36	—	—
CdSe	95·2	1250	1·7	—	—	—	200	—	—	—	—
CdTe	120·5	1040	1·4	—	—	10·4	600	50	0·34	—	—
HgS	116·0	583	—	—	—	—	—	—	—	—	—
HgSe	140·0	690	~0·2	—	—	—	10000	—	—	—	—
HgTe	164·0	670	0·02	—	—	—	17000	—	—	—	0·02

TABLE 4
IV-VI Compounds

	Atomic Weight M	Melting Point (°C)	Energy Gap Q (eV)	Debye Temperature θ (°K)	Dielectric Constant ε: L.F.	Dielectric Constant ε: H.F.	Mobility: Electrons μ_e ($cm^2\ V^{-1}\ sec^{-1}$)	Mobility: Holes μ_h ($cm^2\ V^{-1}\ sec^{-1}$)	Ratio of Effective Mass to Free Electron Mass: Electrons m_e	Ratio of Effective Mass to Free Electron Mass: Holes m_h	Thermal Conductivity K_0 (W/cm°C)
PbS	120·0	1110	0·37	194	70	17·4	600	400	0·15	—	—
PbSe	143·0	1065	0·26	—	—	20·7	900	500	—	—	—
PbTe	168·0	904	0·29	—	—	30·0	300	300	0·3	—	0·023

scattering, and much less than that in diamond or silicon, as shown in Table 1. There is in addition great difficulty in achieving crystal perfection because of the 'stacking-disorder' typical of this material. It is possible that more perfect crystals would give higher mobility than that listed, though still below that of silicon. Such low values are not very useful for transistors, but are acceptable for rectifiers; silicon carbide rectifiers can be operated above 500°C.

Group III-V Compounds

These compounds have a diamond-type crystal structure similar to that of germanium and silicon, and have partly covalent, partly ionic binding. Their electrical properties are listed in Table 2 and it will be noted that gallium arsenide and indium phosphide are suitable as regards gap-width and mobility for high-temperature high-frequency transistor operation. The life-time obtained so far is, however, inadequate for good transistor performance. High lifetime is not required for high-speed switching, or in variable reactance diodes for parametric amplifiers. For the latter their high mobility and relatively high gap-width make gallium arsenide and indium phosphide of particular interest. The mobility is high also in indium arsenide and especially in indium antimonide, but these have low gap-width. They are important for Hall effect applications and as photo-conductors sensitive in the infra-red.

In both gallium arsenide and indium phosphide, the mobilities refer to material with an impurity density not much below $10^{17}/cm^3$. This represents the highest purity obtainable so far. The mobilities as listed are quite high, but are no doubt depressed by impurity scattering. If these compounds can be further purified, electron mobilities near 10 000 are probably attainable in both. The impurities causing low lifetime must have deep seated energy levels at which recombination occurs, as distinct from shallow donor or acceptor levels. This suggests that several types of impurity remain present in the best samples of these compounds made so far.

Group II-VI Compounds

Compounds between Group II and Group VI elements have either hexagonal or cubic structure. Their properties are indicated in Table 3. They are more ionic and have larger gap-width than group III-V compounds of similar atomic weight. Zinc and cadmium sulphides are insulators in the pure state, and are of interest mainly as phosphors and photo-conductors. Cadmium sulphide with suitable impurity can, however, have a conductivity exceeding $1\Omega^{-1}cm^{-1}$. Donor levels are obtained by substituting either Group III atoms for the Group II or Group VII for the Group VI. Correspondingly acceptor levels are obtained by substituting Group I atoms for the Group II or Group V for the Group VI. The mobility is low for the compounds of low atomic weight, but large for electrons in mercury telluride and selenide, where there is less ionicity in the bond, and the effective masses are low. These, however, have low gap-widths. Cadmium sulphide and selenide are good photo-conductors, sensitive to visible light, in spite of the rather low mobility. This is because there is a large increase in electron population for a small light input, and a large lifetime for these excess electrons. This appears to arise from the details of the recombination and trapping processes characteristic of these crystals. Unfortunately the long lifetime associated with the high sensitivity results in a speed of response too slow for some applications. (~0·1sec for CdS and ~0·01sec for CdSe.) Research on these compounds is very active at the present time, and further improvements in performance can be expected.

Both CdS and CdTe can also give photovoltaic effects, with a high response to red light, so that they are potentially valuable for solar battery applications. pn junctions can now be prepared in both, but so far they rarely have the characteristics expected on the basis of energy gap and resistivity.

Group I-VII Compounds

These compounds are still more ionic than the group II-VI elements, and have high gaps and low mobilities. The alkali-halides are of no interest as semiconductors, and in fact have ionic conductivity at temperatures below those at which intrinsic electronic conductivity appears. Because of low dielectric constant, the ionization energy of impurity centres is high, so that extrinsic conductivity is very small. With the silver halides photo-conductivity plays a significant part in the photographic process, but otherwise semiconductivity is not important in them.

Group IV-VI Compounds

Lead sulphide, telluride and selenide have a rock salt structure indicating that the lead in these compounds is effectively divalent. Their properties are shown in Table 4. The interest in these until recently has mainly been in the photo-conducting properties in the infra-red, but recently lead telluride and selenide have also become important as thermoelectric materials, as discussed further below.

Other Binary Compounds

Various other families of binary compounds have been studied to a limited extent, with results as in Tables 5, 6 and 7. With all these materials, real understanding will be obtained only when single crystals of stoichiometric material have been prepared with uniform properties, when the mobility has been measured over a wide range of carrier density, and when at least some studies such as cyclotron resonance have been carried out giving information about the effective mass. This represents a considerable programme, the initial work in preparing and controlling good-quality single crystals being difficult in many cases, especially when constituents are volatile at or below the melting point. Some of these compounds are finding applications because of their thermoelectric properties, as discussed below.

Ternary Compounds

The preparation, control of purity and stoichiometry, and growing of single crystals becomes more difficult in ternary systems. Most study has been done so far on Group I-III-VI compounds (chalcopyrites) which are analogues of the compounds between Group II and Group VI elements, on Group II-IV-V compounds which are analogues of the Group III-V compounds, and on Group I-V-VI compounds. Their properties are listed in Tables 8, 9 and 10.

TABLE 5

II-IV Compounds

	Atomic weight M	Melting point (°C)	Energy gap Q (eV)	Mobility electrons μ_e ($cm^2 V^{-1} sec^{-1}$)	Mobility holes μ_h ($cm^2 V^{-1} sec^{-1}$)
Mg_2Si	26	1100	0·77	400	60
Mg_2Ge	41	1150	0·74	280	110
Mg_2Sn	56	770	0·36	300	250
Mg_2Pb	85	550	? Metallic	—	—
Ca_2Si	36	920	1·9	—	—
Ca_2Sn	66	1120	0·9	—	—
Ca_2Pb	96	1110	~0·5	—	—

TABLE 6
V-VI Compounds

	ATOMIC WEIGHT M	MELTING POINT (°C)	ENERGY GAP Q (eV)	DEBYE TEMPERATURE θ (°K)	DIELECTRIC CONSTANT ε	MOBILITY ELECTRONS μ_e (cm² V⁻¹ sec⁻¹)	MOBILITY HOLES μ_h (cm² V⁻¹ sec⁻¹)	THERMAL CONDUCTIVITY K_o (W/cm °C)
Bi_2Te_3	160	575	0·15	145	85	420	400	0·016
Bi_2Se_3	131	706	0·27	—	—	~600	—	—
Sb_2Te_3	125	620	? metallic	—	—	—	~300	0·05
Sb_2Se_3	96	617	1·2	—	—	~100	—	—
Bi_2S_3	103	—	1·3	—	—	200	—	—
Sb_2S_3	68	—	1·7	—	—	—	—	—
As_2Te_3	107	—	~1·0	—	—	170	.. 80	0·02
As_2Se_3	77	—	~1·5	—	—	—	—	—

TABLE 7
III-VI Compounds

	MELTING POINT (°C)	ENERGY GAP Q (eV)	MOBILITY ELECTRONS μ_e (cm² V⁻¹ sec⁻¹)	MOBILITY HOLES μ_h (cm² V⁻¹ sec⁻¹)
Ga_2Te_3	793	1·3	—	—
In_2Te_3	667	1·0	—	—
GaSe	—	2·0	40	20
GaTe	—	1·7	—	—
InSe	—	1·8	—	—
TlSe	—	0·6	—	—

TABLE 8
I-III-VI Compounds

	MELTING POINT (°C)	ENERGY GAP Q (eV)	MOBILITY ELECTRONS μ_e (cm² V⁻¹ sec⁻¹)	MOBILITY HOLES μ_h (cm² V⁻¹ sec⁻¹)	THERMAL CONDUCTIVITY K_o (W/cm°C)
$AgInS_2$	—	1·9	—	—	—
$CuInS_2$	—	1·2	—	—	—
$AgInSe_2$	773	1·2	—	—	0·03
$CuInSe_2$	990	0·9	1010	50	—
$AgInTe_2$	680	0·95	—	100	—
$CuInTe_2$	780	0·95	—	—	—
$CuFeS_2$	875	0·5	—	—	—
$CuFeSe_2$	574	0·15	—	<20	—
$CuFeTe_2$	740	0·10	—	<50	—
$CuGaSe_2$	1040	1·6	—	—	—
$CuGaTe_2$	870	1·0	—	60	—
$CuTlSe_2$	405	—	—	—	—
$CuTlTe_2$	375	—	—	—	—
$AgGaSe_2$	850	1·7	—	—	—
$AgGaTe_2$	720	1·1	—	—	—
$AgTlSe_2$	328	0·7	—	—	—
$AgTlTe_2$	290	—	—	—	—
$AgFeSe_2$	737	0·23	>250	70	0·03
$AgFeTe_2$	680	0·3	>2000	150	0·03

TABLE 9
II-IV-VI Compounds

	ENERGY GAP Q (eV)		ENERGY GAP Q (eV)
$ZnSiAs_2$	2·1	$CdSnAs_2$	—
$ZnGeP_2$	2·2	$ZnSnP_2$	2·1
$CdGeP_2$	1·8	$CdSnP_2$	1·5
$ZnGeAs_2$	~1·0	$BeSiN_2$	>3·0
$ZnSnAs_2$	—	—	—

TABLE 10
I-V-VI Compounds

	MELTING POINT (°C)	ENERGY GAP Q (eV)	MOBILITY ELECTRONS μ_e (cm² V⁻¹ sec⁻¹)	MOBILITY HOLES μ_h (cm² V⁻¹ sec⁻¹)
$CuSbSe_2$	452	—	—	—
$AgSbSe_2$	636	~0·7	—	1500
$AgSbTe_2$	556	~0·6	—	75
$AgBiSe_2$	762	—	—	—

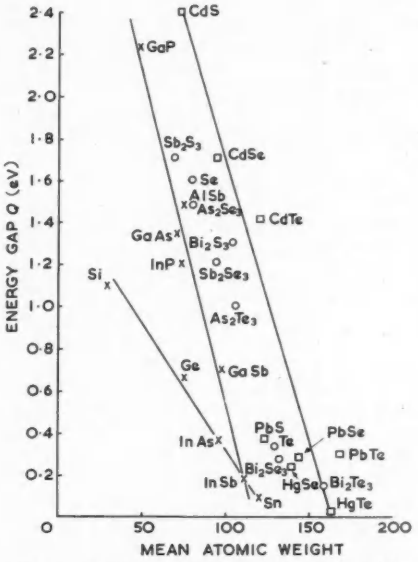

Fig. 3. Variation of energy gap with atomic weight

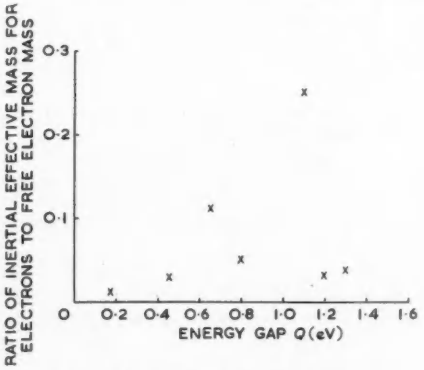

Fig. 4. Variation of effective mass with energy gap

General Relations

It will be noted that in each class of compound the energy gap Q falls as atomic weight M rises, Fig. 3. This is consistent with the decrease in bond-energy in a covalent bond as M rises. Variations in electronegativity-difference between the atoms lead to variations in the details of the relationship between Q and M, superposed on this general trend. According to the simplest theory of energy bands, the effective mass is expected to vary directly with Q, but in fact this is not generally the case, as shown in Fig. 4.

This would probably apply if the variation in Q arose directly from the relative motions of one valence band and one conduction band as M varied. However, the band structure is complex, and the conduction band in particular in the diamond-structure crystals has several components. As M varies, the identity of the component in which the minimum energy occurs may also vary. When this happens there will be a switch from one relationship between effective mass and gap-width to a different one, since this relationship is not the same for the different components. Correspondingly, according to the simple theory, μ should rise systematically as Q falls, and therefore M rises. Again this is not universally so, as shown in Fig. 5. It is true however that the highest mobilities are encountered in low-gap semiconductors, and that mobility rises as Q falls and M rises in each class of material. There are however other important factors, resulting in different values of μ for similar gap-widths, comparing different classes of compounds. These differences arise from the variation in the

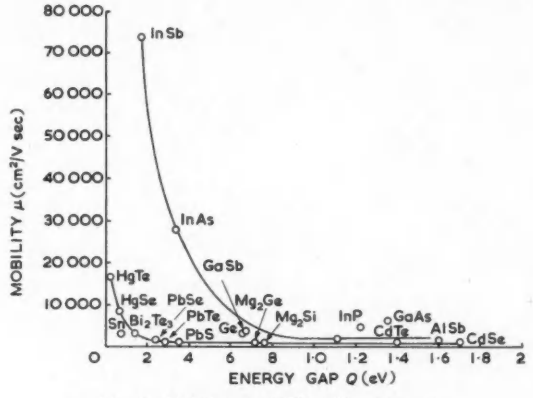

Fig. 5. Variation of mobility with energy gap

details of the bonding and crystal structure, and from the variation in electro-negativity of the ions in the compounds in a given type of bond.

Thermoelectric Applications

Considerable interest has developed recently in the possibility of thermoelectric refrigeration* and generation of power. This subject requires separate mention, as considerations arise other than mobility and lifetime. For either application it is possible to define a figure of merit $z = \alpha^2\sigma/K$, where α is the thermoelectric power and K the thermal conductivity. These three quantities, α, σ and K are inter-related in a semiconductor, and it can be shown that z has a maximum value for any material provided it is 'doped' to give a thermoelectric power near $200\mu V/°C$. The thermojunction will be formed between n- and p-type material, so that the e.m.f. produced by the junction will be $400\mu V/°C$. Provided this is achieved, in the case of lattice scattering in a semiconductor with covalent bonds, $z \propto N/m_i K_o$. Here N is the number of 'valleys' in the band-structure; N is 4 for electrons in germanium, 6 for electrons in silicon and unity for electrons in InSb. m_i is the 'inertial' effective mass which determines the mobility. K_o is the component of thermal conductivity due to the lattice vibrations, as distinct from the component K_e due to electrons. The total thermal conductivity $K = K_o + K_e = K_o + A\,(k/e)^2\sigma T$. K_o is found to decrease as atomic weight M increases in any class of material, as shown in Fig. 6. It will be noted that the alkali halides have lower values of K_o than covalent-bonded materials of similar atomic weight. However, they are of no value for thermoelectric applications because of low μ and low dielectric constant, as discussed above. The value of N cannot at present be predicted for any semiconductor, and does not appear to vary in any systematic way with atomic weight.

Since in any family of semiconductors m_i and K_o both fall as atomic weight rises, for thermoelectric applications attention has been concentrated on compounds with high values of M, and the best thermoelectric materials known so far are bismuth telluride, Bi_2Te_3 and lead telluride, PbTe, and more complex materials made from these by substituting elements from the same columns of the periodic table, e.g., Sb for Bi, or Se for Te. Such substitution lowers the value of K_o, in many cases without

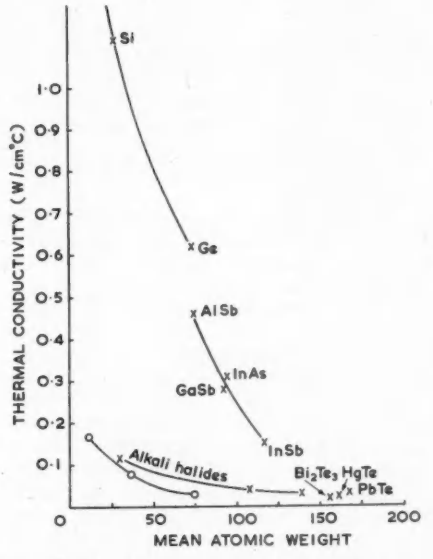

Fig. 6. Variation of thermal conductivity with atomic weight

lowering the mobility. In this type of application the electrical conductivity σ is required to be relatively high (the particular value desired is that which matches a thermoelectric power of $200\mu V/°C$), and relatively high carrier densities are necessary, of the order $10^{18}/cm^3$. Thus the extreme conditions of purity and crystal perfection required for transistor operation are not necessary for thermoelectric applications; while μ should be as high as possible, one has in fact to be content with the value characteristic of a heavily doped material, which as shown earlier is likely to be less than that which can be obtained in the pure material (unless indeed screening effects reverse this trend). Further imperfection in the crystal due to substitution of an atom of different size is likely to have little further effect in lowering μ. Moreover, this situation means that ternary compounds such as those listed in Tables 8, 9 and 10 are possibly of interest if K_o is low; it will be even more difficult to produce these in good quality crystalline form, stoichiometric and free from impurity, than is the case with binary compounds. This does not necessarily disqualify them however for thermoelectric applications, as it would for transistors. Research on these compounds is very active in many laboratories at present in case some of them prove superior to those based on bismuth telluride.

* *See page 690, this issue.*

V.S.W.R. Indicators with Automatic Read-Out

By M. Kollanyi*, M.Sc., A.M.Brit.I.R.E., and R. M. Verran*, B.Sc.

An automatic indicator giving a direct read-out either on a meter or a digital display unit can replace the conventional v.s.w.r. indicator with its time taking adjustments. The circuits can be used with any slotted line or equivalent device. A single movement of the probe carriage is all that is necessary for the instrument to supply the correct v.s.w.r. reading.

The system described is based on a maximum-minimum detector that detects and stores the extreme values of the voltages encountered during the recording cycle. The ratio of these voltages can be calculated by various electronic methods which are also described.

A residual v.s.w.r. of <1·05 is attainable with a maximum range of v.s.w.r. measurement of 1 : 3 or more if required, although this range depends on the method chosen.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

MOST readers will be familiar with the tedious and time consuming nature of v.s.w.r. measurements made with a slotted line. First, the cavity of the slotted line must be tuned to the signal source, then the position of an antinode must be found and the gain of an amplifier used with the system adjusted precisely, and finally the position of a node must be found and the ratio of the two levels determined.

This article describes some of the methods devised and circuits constructed by the authors in an attempt to reduce this labour to a minimum. However, before proceeding with the description of these circuits, it is useful and instructive to consider some of the other methods for automating v.s.w.r. measurement that are at present in use.

A system which causes the probe carriage of the slotted line to be mechanically reciprocated has obvious advantages, but does not really get to the heart of the problem as the maximum and minimum values of the probe output must still be found and their ratio determined as before.

All that has been saved is the movement of the probe carriage to find the positions of a node and an antinode. Usually with this arrangement the probe output is displayed on an oscilloscope, and in this case the gain of an amplifier must still be adjusted to set a level to a predetermined mark.

A better approach to the problem is to feed the output from the probe into an amplifier with an extremely high degree of automatic gain control. This sets the maximum output from the amplifier to a fixed level, and to determine the v.s.w.r. it is sufficient to measure the minimum value. If this system is used in conjunction with a reciprocating probe carriage, then it is possible to obtain a persistent reading on a meter or other indicating device.

Other methods are based on the directional properties of various devices, such as the magic-T. With the magic-T, if arm 3 is connected to a matched generator and the impedance to be measured is connected to arm 4, then the v.s.w.r. can be computed from the voltages existing at arms 1 and 2.

The directional coupler, as its name implies, is capable of discriminating between two directions of propagation possible on a line, so that the forward and reflected components can be separated and their amplitudes measured separately.

The multiple probe system also has its shortcomings although it provides a conveniently readable display. It is difficult to maintain the setting of the probes and to keep the sensitivity of the detectors constant at various frequencies.

The disadvantage of most of these systems is that they are not applicable to existing slotted lines, and in some cases they require a complex mechanical arrangement for their functioning. With the directional coupler and magic-T type of arrangement there is the alternative disadvantage that the phase information about the load is suppressed,

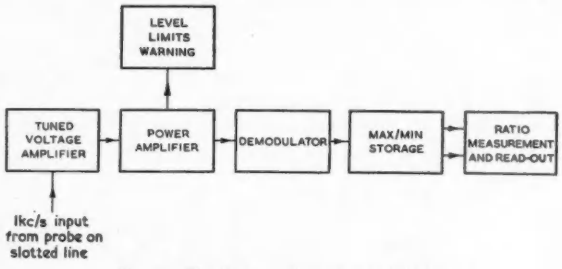

Fig. 1. The direct reading v.s.w.r. indicator

although this information is often as important as the information about the magnitude of the v.s.w.r.

The system to be described does not suffer from these disadvantages. It is readily applicable to any existing conventional slotted line, and the only modification that is necessary is to mount a switch on the probe carriage. One movement of the carriage backward and forward along the slotted line with this switch is sufficient for the instrument to compute the v.s.w.r. existing on the line and display the answer as a stationary reading on a meter. The instrument is also capable of functioning as a conventional v.s.w.r. indicator if for some reason this should be desired.

It is claimed that in many cases a more accurate answer is obtainable with this system than by conventional means, for the time taken to obtain a reading is so much reduced that there is correspondingly less time for the signal frequency or amplitude to drift.

Discussion

The system developed by the authors (Fig. 1) is based on a circuit which extracts and stores the extreme values of the voltages encountered when moving the probe along the slotted line. To be able to do this, it is first necessary to detect the envelope of the microwave signal from the probe and amplify it with a selective amplifier in the conventional way.

The envelope of this audio frequency signal is, in turn, obtained from a demodulator stage the time-constant of which is chosen so that its output signal can follow the amplitude of the microwave signal along the standing wave

* *Marconi Instruments Ltd.*

pattern. To be able to do this without significant error, the time-constant of the demodulator circuit must be less than 0·02sec. This requirement is based on the assumption that the speed of the probe carriage does not exceed half a wave length per second.

The output of this demodulator stage is used to operate the circuit which extracts and stores the extreme values. This circuit, shown in Fig. 2, consists fundamentally of rectifiers and capacitors arranged in such a way that during the recording process the signal from the demodulator charges C_1 through MR_1 to its peak value, while C_2 discharges through MR_2 into the demodulator to the lowest

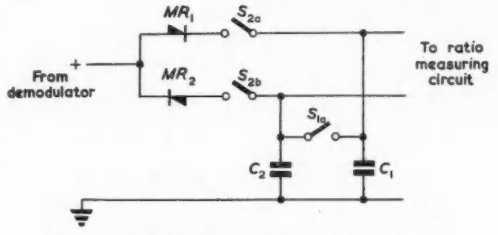

Fig. 2. Maximum and minimum storage circuit

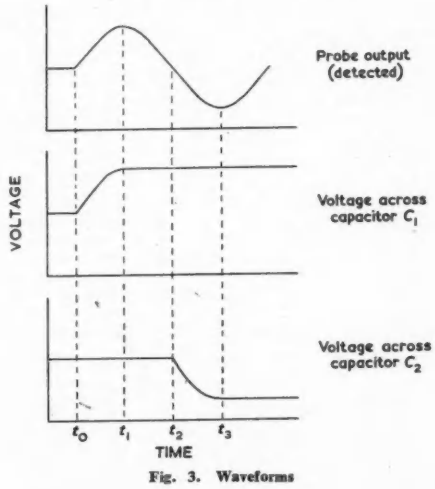

Fig. 3. Waveforms

voltage produced. To carry out the recording process the operator has merely to move the probe carriage once along the slotted line.

The purpose of S_1 is to provide an initial charge on C_2 which must always be greater than the expected minimum. This initial charge is supplied through MR_1, and consequently at the beginning of the recording period C_1 and C_2 will have equal voltages (Fig. 3). As soon as the switch is released (t_0) and the carriage is moved the voltages on the two capacitors will vary independently.

In Fig. 3, it has been assumed that the voltage change begins by increasing; consequently the voltage on C_1 increases also, while that on C_2 remains unchanged. At t_1 the voltage reaches its peak value, and from this time the voltage on C_1 will not change. Moving the probe further the potential falls below the initial value at t_2, and at this point MR_2 starts conducting and will discharge C_2 until the voltage across this capacitor reaches the minimum value at t_3, where it will remain.

Due to the square law of the microwave detector, this process gives two voltages proportional to the square of the extreme values on the line. The result is not affected by the speed of the carriage as long as the time-constants of the circuit are negligible. The two voltages are stored in C_1 and C_2 for further processing by the ratio measuring circuit.

Some difficulties were encountered in designing the demodulator, mainly owing to the conflicting nature of the requirements placed upon it. Not only must it be linear within wide voltage limits, but a low time-constant and a low amount of ripple are imperative. The values actually used ($C = 1\mu F$, $R = 33k\Omega$) appear to be a good compromise between low ripple and low time-constant.

The wide voltage limits are important in order to avoid the necessity of adjusting the gain of the selective amplifier too often. A usable output ratio of 1:40 from the demodulator is desirable in order to cover the voltage standing wave ratio change $\sigma = 2{\cdot}5$ twice.

At first, germanium diodes were used in the demodulator, but although they had a relatively good performance at low levels, their output became non-linear at higher volt-

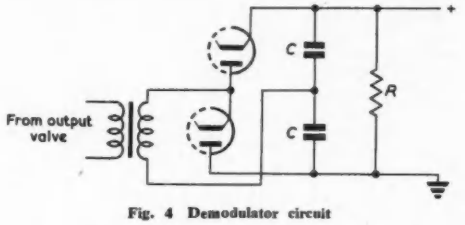

Fig. 4 Demodulator circuit

ages. Since it was impossible to reach the 120V upper limit aimed at they were discarded and replaced by thermionic diodes.

The diodes are connected in the form of a voltage doubler circuit, as shown in Fig. 4. The output from this demodulator is in perfectly linear relationship with the input voltage except at very low voltages, where the linearity is impaired by the 'splash' current of the thermionic diodes. This maintains a constant voltage at the output in the absence of any input and imposes a lower limit on the output voltage for a given limit of error.

To determine the magnitude of this lower limit, let the case be considered when the maximum signal voltage is a, the minimum signal voltage is b, and the splash voltage is e. In the absence of splash voltage the standing wave ratio (σ) measured would be

$$\sigma = \sqrt{(a/b)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(taking into account the square law of the first detector) With the splash voltage, however

$$\sigma' = \sqrt{\left(\frac{a+e}{b+e}\right)} = \sqrt{(a/b)}\sqrt{\frac{1+(e/a)}{1+(e/b)}} \quad \ldots\ldots (2)$$

Ignoring second order terms

$$\sigma' = \sigma\left(1 + (e/2a)\right)\left(1 - (e/2b)\right) \quad \ldots\ldots\ldots (3)$$

and

$$\sigma' = \sigma\left(1 + (e/2a) - (e/2b)\right) \quad \ldots\ldots\ldots (4)$$

Now the proportional error $P = \dfrac{\sigma - \sigma'}{\sigma}$ ..... (5)

or, substituting,

$$P = (e/2)\left(\frac{a-b}{ab}\right) \quad \ldots\ldots\ldots\ldots (6)$$

Since $a = b\,\sigma^2$ this may be expressed as

$$P = (e/2b)\,\frac{\sigma^2 - 1}{\sigma^2} \quad \ldots\ldots\ldots\ldots (7)$$

If the maximum permissible error is fixed at 2 per cent, and $\sigma_{max} = 2{\cdot}5$ then

$$b_{min} = e/2P\frac{\sigma^2 - 1}{\sigma^2} = 21e \text{ volts.}$$

In the actual circuit the splash voltage was approximately 0·5V, setting the limit for the lowest voltage to approximately 10·5V.

The maximum voltage available from the demodulator is 150V, so the r.f. voltage ratio range actually covered is $\sqrt{(150/10{\cdot}5)} = 3{\cdot}8$. This gives a sufficient margin around v.s.w.r. $\sigma = 2{\cdot}5$ to make frequent gain control adjustments unnecessary.

It is advisable to incorporate a warning system that gives an indication to the operator when the voltage limits to be observed are exceeded. This can be operated from the power stage driving the final demodulator.

So far voltages proportional respectively to the square of the maximum and minimum voltages existing on the slotted line have been stored in two capacitors. During the read-out period these two voltages are processed in

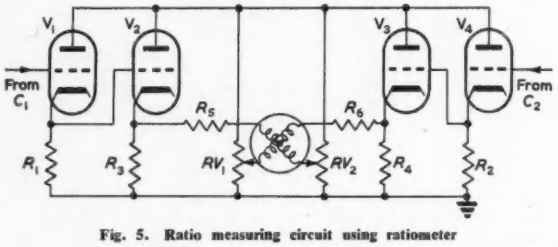

Fig. 5. Ratio measuring circuit using ratiometer

order to display their ratio either directly or in a logarithmic form.

It would appear that the most straightforward method would be to use a crossed coil ratiometer, which could be connected to the two capacitors via cathode-followers in order to obtain a permanent reading. However, some care is necessary in order to maintain acceptable accuracy. The output voltage of a cathode-follower is not zero for zero input voltage, and so some form of backing off device must be used. Furthermore, the output voltage must remain linear with the input voltage even when a current of several milliamperes is being supplied to the ratiometer coil.

These considerations have led to the final circuit, shown in Fig. 5. A double cathode-follower is used so that a high input impedance and low output impedance can easily be obtained. In the interests of simplicity the backing off device chosen was a potentiometer rather than the more elegant method of using a similar cathode-follower.

It might be thought that the limitations imposed on the voltage range over which the instrument operates as a ratiometer would limit its usefulness, but this was not found to be a problem as these limits are far wider than those of other parts of the system such as the demodulator and power output stages. A more serious objection is that once the ratiometer itself is designed nothing can be done to change the scale shape and it is difficult to modify simply the range over which the instrument will compute ratios.

Some other methods, relying almost exclusively on the exponential discharge of capacitors, were tried in order to overcome the limitations of the ratiometer. One of these systems measures the time necessary to equalize the voltages on the two capacitors, and is shown in Fig. 6.

Consider the two capacitors C_1 and C_2 charged to V_1 and V_2 volts respectively, V_1 being the greater.

If C_1 is discharged through a resistor R_1 to V_2, then the time required for this will be t according to the formula

$$V_2 = V_1 \exp(-t/R_1C_1) \quad \ldots\ldots\ldots\ldots \quad (8)$$

Since

$$\sqrt{(V_1/V_2)} = \sigma$$

Then

$$t = 2R_1C_1 \ln \sigma \text{ or } t = K \ln \sigma \quad \ldots\ldots\ldots \quad (9)$$

Thus it is seen that the time required to equalize the two voltages is directly proportional to the logarithm of the v.s.w.r.

The operation of the system shown in Fig. 6 is simply to discharge C_1 through a resistor until no difference can be detected between its voltage and that of C_2. The zero detector is isolated from the storage capacitors by two cathode-followers, and a chopper samples the voltage on the cathode of this valve. The output from the chopper

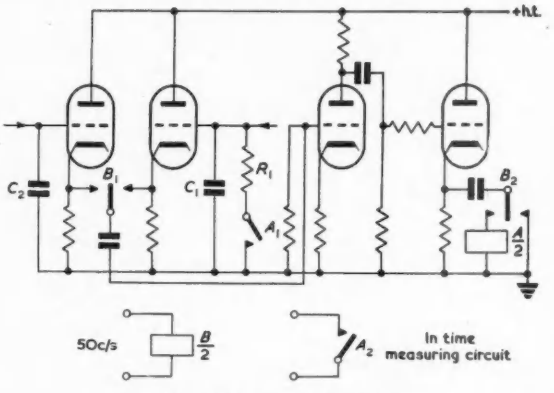

Fig. 6. Voltage equalizing circuit

is, amplified then rectified by a second chopper and used to operate the relay which discharges C_1.

The accuracy with which the zero may be detected by this method depends greatly on the mechanical chopper used and the gain of the amplifier following it. In the circuit built the zero was detected with an inaccuracy of only a few millivolts, which gave a very low error in the indicated v.s.w.r.

The time measuring system used is shown in Fig. 7. An initially charged capacitor is discharged through a resistor for the same time as is necessary to equalize the maximum and minimum voltages, and the change in voltage is measured by a valve-voltmeter circuit incorporating a differential system to compensate for the effects of leakages.

The range of v.s.w.r. measurement may be altered by adjusting the potentiometer RV and so altering the initial voltage to which the capacitor is charged, at the same time adjusting the compensating voltage.

A different system, also based on the exponential discharge of the storage capacitors but which obviates the need for the chopper is shown in Fig. 8. In this system the two capacitors C_1 and C_2 are connected to separate discharging resistors after the recording period.

The voltages across these two resistors are used to control two Schmitt trigger circuits, so that the ratio of the two initially stored voltages is converted into a time difference that can be measured by some method such as the one previously described.

The top end of the discharging resistor is connected to

the grid of V_{1a} (Fig. 9), and the various circuit potentials are so chosen that when the voltage across this resistance is zero, V_{1a} is non-conducting.

When the resistance is connected to its associated storage capacitor after the recording period, the increased voltage on V_{1a} grid makes it conduct, while V_{1b} ceases to conduct, and the circuit remains in this condition until the voltage on the capacitor drops below a predetermined level, when V_{1b} again conducts and V_{1a} becomes non-conducting. A negative pulse is derived from V_{1b} anode when this happens, and this pulse together with the similar pulse from the other trigger circuit operates the time measuring circuit.

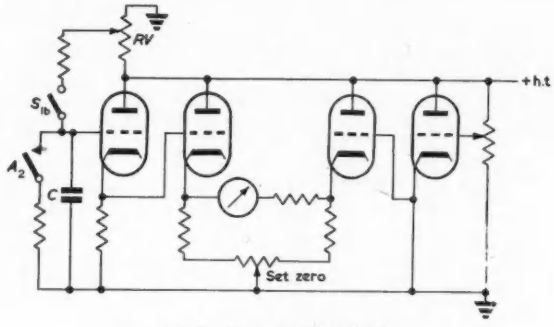

Fig 7. Time measuring circuit

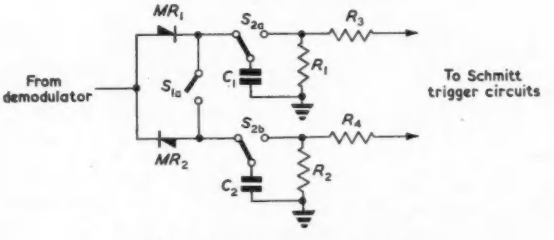

Fig. 8. Simultaneous discharge system

The clamping valve V_{2a} reduces the voltage swing on the cathode of V_1 and so reduces the hysteresis in the operation of the trigger circuit.

To consider the quantitative relationships involved in this method, suppose that two capacitors C_1 and C_2, charged respectively to V_1 and V_2 volts are discharged through resistors R_1 and R_2 to the same voltage v. The times t_1 and t_2 for the voltages to fall to this value will be given by

$$v = V\,e^{-t/RC}$$

or

$$t = RC\,(\ln V - \ln v) \quad \ldots\ldots\ldots\ldots \quad (10)$$

If now $R_1C_1 = R_2C_2 = T$

Then

$$t_1 - t_2 = T\,(\ln V_2 - \ln V_1) \quad \ldots\ldots\ldots \quad (11)$$

or

$$t_1 - t_2 = T \ln (V_2/V_1) = \tau \quad \ldots\ldots\ldots \quad (12)$$

This methods lends itself to the production of a read-out in digital form by using the pulses derived to start and stop an electronic counter working with a fixed frequency oscillator. By suitable choice of the discharge time-constants and the oscillator frequency, the counter may be made to indicate the ratio of the two voltages (the v.s.w.r.) directly in decibels.

If V_1 is the maximum stored voltage and V_2 the minimum one, then v.s.w.r. on the line is $\sqrt{(V_1/V_2)}$.

Expressed in decibels, this is

$$20 \log \sqrt{(V_1/V_2)} \quad \ldots\ldots\ldots\ldots \quad (13)$$

or

$$\sigma\text{dB} = 10 \log e \,.\, \ln (V_1/V_2) \quad \ldots\ldots\ldots \quad (14)$$

It has already been shown above that the time difference τ measured when discharging V_1 and V_2 with equal time-constants will be

$$\tau = T \ln (V_1/V_2) \quad \ldots\ldots\ldots\ldots \quad (15)$$

If the oscillator is of frequency fc/s, then in a time τ the counter will make τf counts.

For accurate readings, the counter should make 100 counts per 1dB v.s.w.r., and so substituting in equation (15):

$$Tf \ln (V_1/V_2) = 100 \quad (10 \log e \,.\, \ln V_1/V_2) \quad \ldots\ldots \quad (16)$$

or

$$Tf = 1\,000 \log e \quad \ldots\ldots\ldots\ldots \quad (17)$$

So, if the oscillator frequency is known, the discharge time-constant may be suitably fixed to make the counter direct reading.

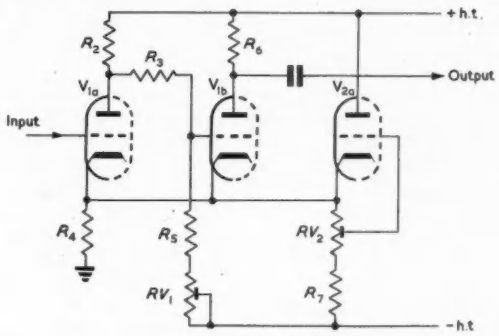

Fig. 9. Schmitt trigger circuit

Apart from the errors already discussed above, there will be further errors in this system if there are differences between the threshold voltages of the two Schmitt trigger circuits or in the time-constants of the two discharging circuits.

Suppose that the two threshold voltages are v and $v+\delta v$ and that the two time-constants are T and $T + \delta T$.

The maximum error will occur when the longer time-constant is associated with the lower threshold voltage, so that if both discharges start from a voltage V, then for one circuit

$$v = V \exp\left(-\frac{-t_1}{T + \delta T}\right) \quad \ldots\ldots\ldots \quad (18)$$

and for the other circuit

$$v + \delta v = V \exp(-t_2/T) \quad \ldots\ldots\ldots \quad (19)$$

From these two equations

$$\ln \frac{v + \delta v}{v} = \frac{t_2}{T + \delta T} \quad - t_2/T \quad \ldots\ldots \quad (20)$$

or

$$t_1 - t_2 = (T + \delta T) \ln \frac{v + \delta v}{v} + t_2\,\delta T/T \quad \ldots\ldots \quad (21)$$

This equation shows that, as would be expected, the tolerance on the threshold voltage must be small compared with this voltage, and that δT must be small compared with T.

The system as described depends greatly on the stability of the changeover voltage of the Schmitt trigger circuits. a stability which can only be achieved by the use of stable components and well stabilized supplies, including the negative supply.

It is possible to greatly simplify the circuits in both the simultaneous discharge and the voltage equalization methods by using the well defined cut-off of modern crystal diodes.

The replacement for the Schmitt trigger circuits is shown in Fig. 10. The voltage existing across the storage capacitor C_1 and its associated discharging resistor R_1 is applied to the diode MR_1 through current limiting and isolating resistors R_2 and R_3.

During the time that the voltage on both the storage capacitors is greater than the biasing voltage V_b, only MR_1 is conducting and so the a.c. signal does not reach the output. As soon as the voltage on C_5 falls to V_b, MR_2 will provide a path to the output for the a.c. signal. When C_1 falls to V_b volts, the diode MR_1 stops conducting and cuts off the a.c. signal.

The time duration of the a.c. signal at the output may either be measured by counting the number of cycles transmitted, or by some other convenient method such as charging a capacitor.

A similar system can also be utilized with the voltage equalizing circuit, as is shown in Fig. 11.

As long as the voltage of C_1 is higher than that of C_2

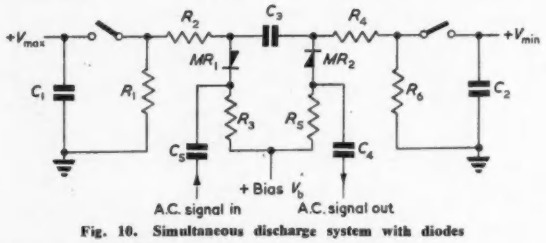

Fig. 10. Simultaneous discharge system with diodes

the diode is biased in the reverse direction, and the a.c. signal is not passed to the amplifier.

When C_1 has discharged through R_1 to the same voltage as C_2, the diode MR_1 starts to conduct, the a.c. signal is passed to the amplifier and having been rectified operates the relay A, ending the discharge. The time required to equalize the voltages can be measured by any of the time measuring circuits mentioned earlier, which can conveniently be actuated by additional contacts on relay A.

With equal voltages on the cathodes of V_1 it is necessary to connect the diode MR_1 as shown so that it receives the slight positive bias necessary before it will start to conduct.

The Mullard OA202 silicon junction diode was found to be very suitable in this application. The amplitude of a.c signal used was 50mV, and the necessary change in d.c. bias between the conducting and non-conducting states was found to be less than 0·1V under these conditions.

Great simplifications could be achieved in the indicating system by the use of logarithmic circuits, and Fig. 12 shows one system that could be used. If the tuned amplifier of the standard system can be replaced either fully or partly by a tuned logarithmic amplifier, then the demodulator will supply voltages proportional to the logarithm of the probe voltage. The maximum minimum detector stores the two extreme voltages, and it is now sufficient merely to measure their difference to measure the magnitude of the v.s.w.r. This can be done either by a 'floating' valve-voltmeter circuit, or by a pair of cathode-followers with a meter between the cathodes. It is even simpler to discharge the voltage difference between the two storage capacitors through an integrating galvanometer. This galvanometer would integrate the discharge current, which integral is proportional to the voltage difference between the two provided that their capacitances are equal. A reading proportional to the logarithm of the v.s.w.r. is then obtained in a steady form.

This circuit automatically reduces the extent of voltage variations at the demodulator, thus allowing greater limits of operation without adjusting the gain of the amplifier.

Practical Details

All the circuits described can only function correctly if the voltage from the demodulator is held between certain limits during the measurement—albeit fairly wide limits. A simple warning circuit was developed to give the operator visual warning if these limits are exceeded (Fig. 13).

This circuit consists of a grid leak detector as the low level indicator and a valve normally biased to cut-off as the high level indicator.

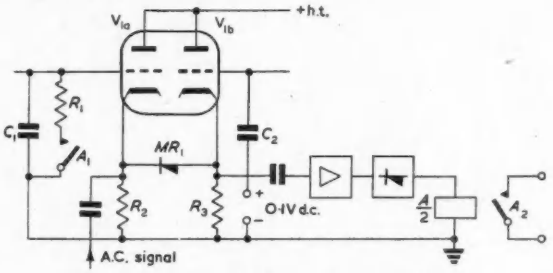

Fig. 11. Voltage equalization system with diode gate

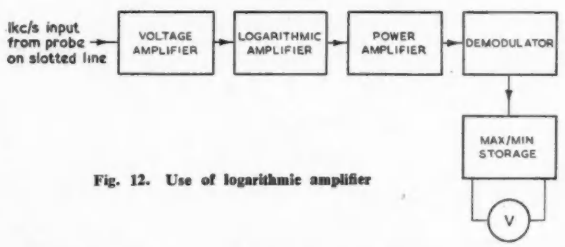

Fig. 12. Use of logarithmic amplifier

In Fig. 13, V_A is the grid leak detector, which gets its signal from the anode of the power stage of the selective amplifier. The grid of V_A is initially biased slightly positive, but above a certain signal voltage (set by RV_1) the valve is cut off as a result of grid rectification, and the neon Lp_1 extinguished. If the voltage of the signal is reduced below this threshold level, the valve starts conducting and the neon lights up giving a warning on the front panel of the instrument.

V_b is biased into cut-off to such an extent that it only starts conducting when the signal level reaches the maximum obtainable from the power output stage before distortion sets in. This maximum value can be set by RV_2, and a second neon Lp_2 on the front panel is lit when the maximum level is exceeded.

The system using a ratiometer as described previously was built around a meter which indicated a maximum ratio of currents in its coils of 10:1. Preliminary tests on the instrument showed that the acceptable ranges of currents for the two coils were 0·1 to 1·0mA and 1·0 to 10·0mA respectively, and also that much better discrimination was obtainable at high than at low ratios. This led to a cathode-follower arrangement which with equal voltages on the storage capacitors, would cause the meter to read full scale.

In order to get the necessary low output impedance from the cathode-follower to be able to supply a maximum of

10mA to the high current coil, and still keep the output voltage linear with the input, it was necessary to use five half sections of 12AT7 valves in parallel as V_2 in Fig. 5. Fortunately, as the other coil of the meter only required a maximum of 1mA one half section of a 12AT7 was suitable as V_3.

The input impedance of the system was kept very high by making the cathode resistors R_1 and R_2 of the first valve of each pair 1MΩ. This high input impedance meant that the meter indication would remain quite steady for many minutes.

The virtues of the cathode-follower-ratiometer system are the simplicity of the switching arrangements necessary and the instantaneous reading obtained on the meter.

The switching sequence is initiated by a control switch mounted on the probe carriage of the slotted line. This is a three position switch, spring loaded to return to the central position and is a convenient method of moving the probe carriage. In this particular case it was arranged that with

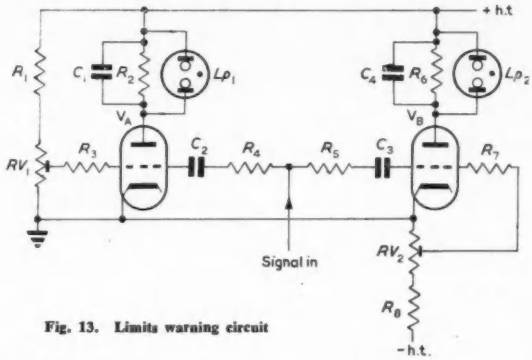

Fig. 13. Limits warning circuit

the control switch in the central position, both S_1 and S_2 (Fig. 2) were open. With the switch in the left position S_1 and S_2 are closed and with the switch in the right position S_2 only is closed. The sequence of operations to take a reading is first to move the control switch to the left, and then having moved the switch to the right, to push the probe carriage along the slotted line and, finally, to release the control switch.

It was arranged for the ratiometer to function as a conventional v.s.w.r. indicator by passing a constant current through one of its coils and connecting the other to the demodulator circuit.

With the system using Schmitt trigger circuits to time the simultaneous discharge of the two storage capacitors, it was obvious from the first that the practical problems would be associated with getting two circuits to work, and more important, to stay working in a precisely similar manner. Very well stabilized positive and negative h.t. supplies were found to be a prime requirement, as were high stability, close tolerance resistors for R_2,R_3,R_5 in Fig. 9. RV_1 and RV_2 allow for differences between valves in the initial setting up procedure.

In this setting up, it is first necessary to ensure that the threshold voltages of the two Schmitt trigger circuits are the same and then to check that the discharge time-constants are equal. Both of these tests are best carried out by observing the residual v.s.w.r. reading on the read-out device when unity v.s.w.r. is measured. (This is best obtained by not moving the probe). With careful adjustment the reading can be kept below 1·02 when this test is carried out. What is more important, it was found that over a period of many weeks the operation of the circuit was such that no further adjustment was needed.

The switching arrangements for this system were rather complex, and to get correct operation a certain sequence had to be followed.

The control switch had first to be moved to the left, which closed S_{1a}, connected the storage capacitors to their charging circuit via MR_1 and MR_2 and connected the meter across the output of the demodulator, where it functioned as a conventional v.s.w.r. indicator. In the time measuring circuit S_{1b} charged the capacitor C to a voltage determined by the potentiometer RV.

On returning the control switch to the central position, all the relays remained operated, but on moving the switch to the right the meter was reconnected to the time measuring circuit and S_1 opened. This is the recording period when C_1 and C_2, the storage capacitors, are charged to their respective voltages. Returning the control switch to the central position connects the storage capacitors to the discharging resistors and initiates the computing period. After a short delay (1 to 2 seconds) the result appears on the meter.

The limit to the accuracy that can be achieved with the voltage equalization system is the accuracy with which the equality of the two voltages on the storage capacitors can be measured. Two stages of voltage amplification and a cathode-follower stage to operate the discharging relay were found to be sufficient.

The equalization of the two voltages could be carried out to within 50mV without any particular refinements to the circuits. Only a simple chopper was used, and no attempt was made to remove hum from the amplifier. The accuracy of the v.s.w.r. measurement achieved was satisfactory, giving a residual v.s.w.r. of approximately 1·05.

Conclusion

Systems have been developed which can take much of the labour from v.s.w.r. measurements using slotted lines and still give access to the important phase information if this is required. Their accuracy is quite sufficient for all normal requirements, and the persistent meter reading gives less chance of reading errors than with the conventional system.

It is felt that these systems might with advantage be adapted for use in other applications where the ratio of two quantities is to be measured. Applications that come to mind are in modulation meters, and in the measurement of noise factor of receivers.

Acknowledgments

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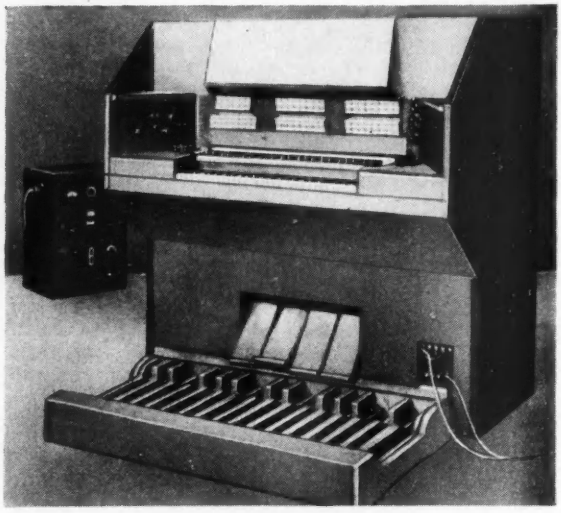
Gas Tubes as Music Generators

By Alan Douglas, M.I.R.E., M.Amer.I.E.E.

The obvious attractions of two electrode gas tubes as relaxation oscillators would suggest that many problems in the generation of electrical music could be economically solved thereby; but, in fact, no commercial instrument uses such devices. Some recent circuits make the best of the inherent physical limitations of inexpensive gas tubes.



(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

As long ago as 1928, W. Kock and O. Vierling designed a two-manual organ using two electrode neon tubes as sawtooth oscillators. At that time, such tubes had reached a higher state of development in Germany than in any other country. An instrument of this kind was then a great novelty, and its vagaries were accepted as a matter of course.

Regardless, however, of the prime source of oscillations, the formation of acceptable tone colours by synthesis was not at that time understood, and because of this we find a lapse of nearly ten years before further developments took place. By this time the hot cathode three-electrode gas tube was well established, and the time appeared ripe for another approach to gas tube oscillators. But such tubes are too costly for polyphonic instruments and this article refers only to inexpensive two electrode cold-cathode tubes.

Because of the basic fact that all gas tubes, on ionization, can pass a considerable current which may be used to discharge a capacitor, it is comparatively easy to obtain a linear sawtooth wave from such oscillators. If the charging current I is held constant, the charge on the capacitor C at any time t after the tube goes out is

$$Q = Q_0 + It$$

where Q_0 is the charge on C at the instant of tube extinction.

The voltage across C and the tube is

$$V = (Q/C) = (Q_0/C) + (It/C) = (V_0 + (It/C))$$

Thus the voltage across C rises linearly during the charging period, and this is important because any departure from linearity will affect the distribution of harmonics; which, in turn, will affect the fidelity of synthesized tones. Should I, for instance, not be constant, then the voltage across C will rise exponentially, and if the line voltage is low, the curvature may be quite serious musically.

While the full charging voltage is usually obtained at musical frequencies, there is generally some uncertainty as to the instant at which the discharge through the tube commences, and even more about the instant at which this ceases. The most important factor controlling this is the configuration of the external circuits associated with the tube. Other things being equal, if the current is so great that the whole of the cathode is covered by the glow, the cathode drop will be high; on discharge, the voltage may fall as A in Fig. 1. If, however, that current is limited in some way so that the cathode is not completely covered by the glow, the cathode drop will not affect the voltage (B in Fig. 1). Although large voltages are not essential in a music generator, there must be a much higher voltage across the tube than the actual ionizing potential of the gas used. This is because the mechanism by which the glow discharge is built up and maintained depends basically on secondary emission from the cathode, due to positive ion bombardment. As this is a relatively inefficient process, it is necessary for each electron leaving the cathode to produce many ionizations en route to the anode. Thus the discharge running voltage will be at least several times the ionization potential. The best voltage for cheap tubes appears to be about 55V.

If, then, the glow does not completely cover the cathode, the voltage drop depends on the gas used, separation of the electrodes, and the work function and purity of the cathode material; and not on the gas pressure. But the current density per unit area of the cathode does depend on the gas pressure; and, of course, the purity and composition of the gases used affects the performance.

It is well known that cold-cathode tubes of this type have an upper frequency limit. This is because ionization is not instantaneous, requiring a time depending on the applied voltage and the amount of original ionization. The mass of the positive ions call for time to cross to the cathode and accelerate sufficiently to produce ionization by collision. The rate of ionization can be increased with an increase in applied voltage, but since the cathode heats up to some extent with the bombardment, the degree of ionization remaining

The above photograph shows the Kock and Vierling two-manual organ.

when the capacitor discharges may be very variable. If the frequency is high enough, there may be ions which have not had time to recombine. The time for deionization is much greater than that for the current to fall to zero in an external circuit having negligible inductance. Therefore the dynamic characteristic of the tube is not quite the same as the static characteristic. At very low frequencies, however, it is more difficult to control the discharge and in the case of an oscillator in which the tube is used to charge a capacitor, it may be difficult to start ionization. As free electrons can be liberated by incident light, one method exposes the oscillator tubes to a weak light source such as a flashlight bulb. Even so, the rate of ionization may be erratic from one instant to another.

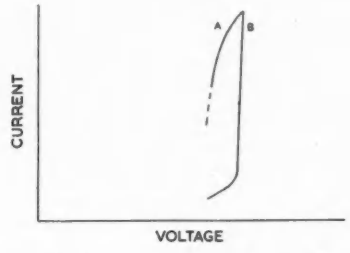


Fig. 1. Current/voltage curve for gas tube

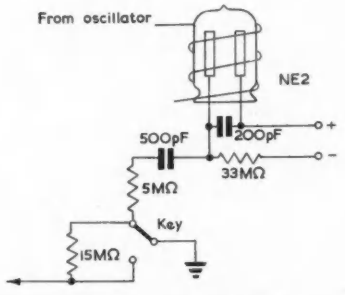


Fig. 2. Method of controlling ignition potential

A method of controlling the ignition potential with some certainty is to provide a magnetic field round the tube. This confines the path of electrons crossing to the anode, and greatly regularizes the action of the discharge. An example of this method is shown in Fig. 2, where an inductance supplied from a previous oscillator is used to increase the locking in a synchronized gas tube frequency divider using very inexpensive tubes (NE2). Such glow tubes have symmetrical electrodes, but it is worth noting that in a tube in which the cathode element is the smaller, the ignition potential is usually lower than if the connexions are reversed. This is a particularly desirable tube on account of its low cost, but discharge is uncertain because of the large physical variations between specimens, especially irregularities over the cathode surface resulting in minor changes in cathode drop. This is a result of cathode material impurity. A particularly irritating effect from this is 'splash' or a random waveform. These give rise to transients, and may occur even with good quality tubes. Severe radio interference can be caused thereby.

All these relatively minor discrepancies add to make it virtually impossible to replace one glow discharge tube of an inexpensive type with another without considerable readjustment of the external circuits. As the impedance of the tube is very low, it is susceptible to external loading and this may distort the waveform. Such loading may take the form of another cascaded divider, for example. It is difficult to assure synchronization over two or three semitones with a cheap gas tube for any length of time, the waveform becoming distorted towards the upper and lower frequency limits. A recent American circuit overcomes this difficulty and also greatly increases the apparent impedance[1].

Fig. 3 shows two gas tubes in series, with series timing capacitors C_5 and C_6. This capacitive voltage divider isolates the output so that loading does not affect the frequency. The two tubes have a high impedance to earth. Capacitors C_3 and C_4 in another divider are 1/100th of the values of C_1 and C_2. As their midpoint is connected to that of V_3 and V_4, the proportion of the output of the first stage at the second stage is nearly proportional to the values of the two capacitors.

Assuming that the negative flyback pulse of the first stage appears before the charge on C_5 and C_6 is high enough to

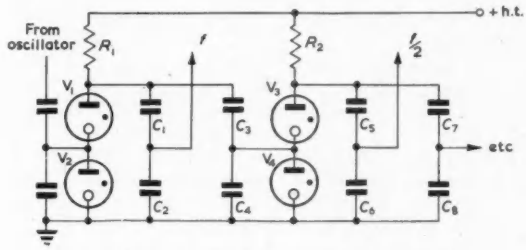


Fig. 3. Gas tubes in series with capacitive voltage dividers

ionize V_3 and V_4 and is applied to the junction of V_3 and V_4; the lower electrode of V_3 then becomes sufficiently negative to ignite it. A higher positive potential then appears on the upper electrode of V_4 and that tube ignites. Capacitors C_5 and C_6 quickly discharge and extinguish V_3 and V_4. Capacitors C_5 and C_6 begin to recharge to produce the rising portion of the second stage output wave. So the first stage triggers the second. Any divided signal fed back to the output of the first stage (a common failing with single tube dividers) must pass through the high impedance voltage divider (C_3 and C_1 in series) and the low impedance shunt divider C_2. Very great attenuation of the fed-back signal is achieved.

Notwithstanding these precautions, a good deal of artificial ageing of cheap neon tubes is necessary to stabilize their performance. Thereafter their behaviour depends to a great extent on how often they are used. Long periods of dis-use frequently result in inability to start and means must be provided to adjust the free-running frequency of such oscillators.

It can be seen that most of the limitations in performance are physical ones, and if the tubes are to remain of an inexpensive type, it would seem impossible to improve their performance to any measurable extent. For the experimenter who does not object to some instability, many ingenious circuits and applications have been devised by Nicholas Langer[2]; and for music generators using three electrode tubes, see Oskar Sala, German patent 917470.

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A Delta Modulation System Using Junction Transistors

By B. E. Williams*, B.Sc.

A delta modulation system, operating at a digit frequency of 14kc/s, is described which provides a simplex speech link with good intelligibility. The equipment has only one manual control, the press-to-talk switch, other adjustments being preset or made automatically. The receiver regenerates the incoming signal by voltage and time slicing before feeding the decoder. The equipment will work satisfactorily over a wide range of ambient temperatures and is suitable for use over equalized lines or radio links. A power supply of between 6 and 12V is required.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

THIS equipment was designed to provide a simplex speech link using a binary code output signal. The pulse repetition rate was to be as low as was consistent with good intelligibility and the number of controls available to the operator was to be a minimum. The equipment would have to work satisfactorily over a wide range of ambient temperatures.

Simple delta-modulation was chosen as the encoding system because it provides better quality at low digit rates than either pulse code or delta pulse code modulation, both of which have the added disadvantage of requiring a frame synchronizing system. A digit rate of 14kc/s was chosen as a compromise between intelligibility and bandwidth required.

Fig. 1 shows a block diagram of the system. The output of the microphone is equalized before being fed to the input of the constant volume amplifier which ensures that the input level to the coder is near optimum for a wide range of microphone output levels. The output of the coder is converted into an alternating-binary (or three level) signal before transmission. This form of signal has no d.c. component and requires less bandwidth than plain binary code.

The input to the receiver is amplified by the constant level amplifier and then fed to a voltage slicer which removes the noise and degradation which may be produced in the transmission path and also converts the signal back to the usual binary form. Pulses derived from the voltage slicer output are used to lock the receiver timing circuits to the frequency of the sender. The slicer output is time sampled with pulses from the receiver timing circuits to reproduce accurately the coder output, which is then decoded and fed to the telephone earpiece.

All the transistors used in this equipment are of the high frequency junction type although in some circuits low frequency transistors could be used.

The Constant Volume Amplifier

The circuit of the constant volume amplifier (c.v.a.) and microphone equalizer is shown in Fig. 2 and consists of the transistors X_1 to X_5 together with the associated components. The microphone used has a frequency response which rises at the rate of 7dB/octave over the band 300c/s to 3kc/s. The equalizer consists of the components R_2, C_1 which have an insertion loss that increases by 6dB/octave so that the overall response of the microphone and equalizer is approximately flat from 300c/s to 3kc/s.

The parameter used to control the gain of the c.v.a. is the input impedance of a grounded base amplifier X_2. The input impedance is inversely proportional to the emitter bias current. The bias current flowing in R_5 is shared

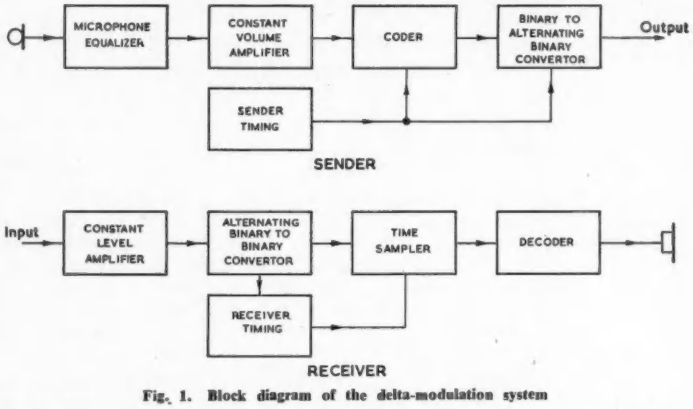

Fig. 1. Block diagram of the delta-modulation system

between the transistors X_1 and X_2 according to the relative potentials of their bases; if the difference is greater than about 0·15V all the current in R_5 flows into the transistor whose base is the more negative. The base of X_2 is held at a fixed voltage by the potentiometer chain R_7, R_8 which is decoupled to audio frequencies by C_6. The input impedance of the control stage, X_2, will then vary over its entire range as the base potential of X_1 is varied by $\pm$0·15V about that of X_2. The output of the c.v.a. is rectified, smoothed and fed back to provide a negative d.c. bias voltage for X_1. For an input signal within the control range the rectified output will be within 0·15V of the reference voltage on the base of the control stage, and should the input level rise, the d.c. bias on X_1 will go more negative and the bias current in X_2 will fall so that the signal input current remains almost constant. The source impedance of the input to the control stage is comparatively low so that the input current is inversely proportional to the input impedance. If the reference voltage is large compared with the 0·3V change in voltage required to control the gain, the difference in amplifier output for signals at extremes of the control range will be small.

The variation in microphone output level is less than 40dB and for this application a 3dB change in output can be tolerated. To obtain the required stability of output the reference voltage should be equal to or greater than 1V and

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for a 40dB control range the ratio of maximum to minimum current in X_2 will be 100. 1mA was chosen as the maximum current so that the minimum will be 10μA. The signal input current, which is constant, must be a fraction of the minimum bias current if non-linearity is to be avoided. The output level from the control stage is therefore low and is amplified by three grounded emitter stages in cascade, X_3 to X_5, giving an overall voltage gain of 10 000 to 40 000,

The source impedance of the rectifier is low compared with R_{27} so the charge time depends on the smoothing components R_{27} and C_{16}. The decay time is determined by C_{16} and R_{24} together with the base current of X_1 which may flow in either direction according to the parameters of the particular transistor used. At high temperatures the collector leakage current flowing in the base of X_1 would, in the absence of R_{28}, charge C_{16} to such a potential that

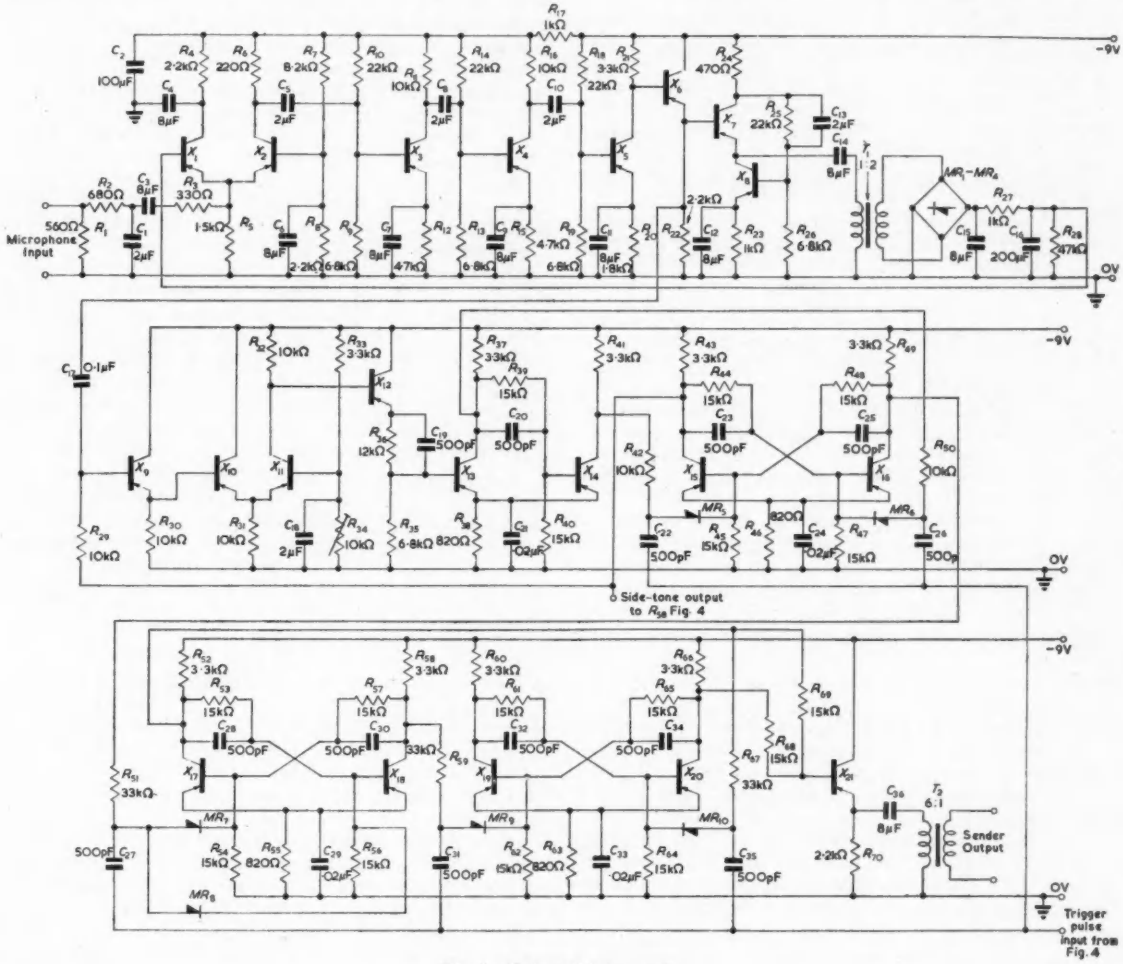

Fig. 2. Delta-modulation sender

depending on the current gains of the particular transistors used. The output of X_5 is emitter-followed by X_6 and fed to the coder and also to a stacked emitter-follower circuit, X_7X_8. This circuit can provide high peak output currents for both positive and negative input signals and so is suitable for driving the full wave bridge rectifier (MR_1 to MR_4). A full wave rectifier is used because the component of the ripple at the input frequency is very small, being due mainly to the differences in forward characteristics of the bridge diodes, with the result that stability is obtained with less smoothing than is required by a half-wave rectifier. The rectifier circuit should have a differential time-constant; that is the d.c. output should be able to increase rapidly to adjust for an increase in input but should decay slowly, in the absence of an input, to bridge over the silent periods between words and sentences.

the rectifier would cease to operate. The resistor R_{28} will prevent this occurring for values of leakage current less than 20μA.

The control stage is unbalanced, i.e. when the gain alters, an output, corresponding to the change in control current through R_{69} is fed to the amplifier stage X_3. To minimize the effect of this unbalance the control stage load has a low resistance (220Ω) so that the d.c. drop across it will be small.

Since the input to the control stage is also applied to the emitter of X_1 the signal current in each transistor will be in the ratio of their bias currents. At high input levels the signal current fed into X_1 will be many times that in the control stage and so the collector of X_1 is decoupled to prevent the input signal by-passing the control stage via X_1 and the supply line.

Referring to Fig. 3 an estimate of the control range of the c.v.a. can be made as follows:

For an input in the control range the output current of X_1, and since $\alpha \simeq 1$ the input current also, is almost constant and equal to V/AR_L amperes peak-to-peak. From linearity considerations let the maximum peak-to-peak input current be limited to $1/N^{th}$ of the control stage bias current whose minimum is then $= NV/AR_L$ amperes. If the input impedance of $X_1 = re = kT/qI_e = 25/I_e$ at room temperature with I_e in milliamperes[1].

$$\text{The maximum input impedance} = \frac{25 \,.\, A \,.\, R_L}{1000 \,.\, N \,.\, V} \text{ ohms}$$

$$\text{maximum input (volts peak-to-peak)} = V/AR_L$$

$$\frac{25 \,.\, A \,.\, R_L}{1000 \,.\, N \,.\, V} = (25/N)\text{mV peak-to-peak}$$

If I_M (mA) is the maximum control current, then control range

$$= \frac{\text{Maximum control current}}{\text{Minimum control current}} = \frac{I_M \,.\, A \,.\, R_L}{1000 \,.\, N \,.\, V}$$

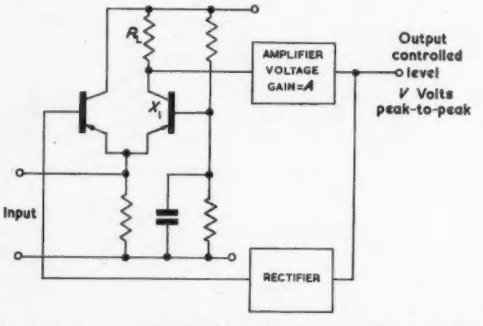

Fig. 3. Constant volume amplifier diagram used to estimate the control range

The assumption is that $re = kT/qI_e$ is accurate for emitter currents greater than about $2I_{co}$. In this circuit at high temperatures I_{co} may be as large as 20μA and the input impedance can be 20 per cent different from the value calculated. This error reduces the control range for a fixed current ratio by 2dB. It is interesting to note that the maximum input voltage depends only on the degree of distortion that can be tolerated. The quality of low digit rate delta modulation systems is such that the distortion produced when $N = 2$ cannot be detected in the decoder output.

The Coding Circuit

The form of delta modulation used in this equipment is a simple system for conveying information, in this case speech, in the form of a train of binary code pulses. The polarity of the pulses indicates whether the input signal is greater or less than an internally generated comparison signal at each digit period. All code pulses represent the same change of input signal amplitude so that this system does not require a frame synchronizing signal. The comparison signal is generated by integrating the binary code output. The comparison and input signals are compared and the difference voltage is used, after amplication, to control the polarity of the next code pulse so that the difference will be reduced. To recover the information at the receiver the binary code is regenerated and then integrated to produce an output, identical to the comparison signal in the coder, which is passed through a low-pass filter and then fed to the telephone earpiece. The d.c. levels in the coder feedback loop are so arranged that in the absence of an input signal the coder output consists of alternate positive and negative pulses. The comparison signal therefore varies about the mean of the binary code voltage levels; this is a suitable operating point because it produces the highest frequency idling pattern and allows equal positive and negative excursions of the comparison signal. A lower frequency idling pattern would produce an audible note in the telephone earpiece. The maximum rate of change of input voltage that the comparison signal can follow is determined by the time-constant of the integrating network and the binary code amplitude. The maximum input amplitude that can be coded at any frequency therefore falls at the rate of 6dB/octave. This slope limitation is no great disadvantage when coding speech because the power spectrum of speech falls at about 6dB/octave above 800c/s so that providing the 800c/s component does not overload the coder the higher frequencies are not attenuated. The accuracy with which the higher frequencies are coded falls because fewer digits are available to define each cycle.

The decoded receiver output contains, in addition to the information transmitted, quantizing noise which is produced in the coding process. The amount of quantizing noise in the output tends to be constant and independent of the amplitude of the signal being coded. The signal-to-noise ratio therefore improves as the input to the coder is increased. It has been found experimentally that with low digit rates it is preferable to slope overload the coder on signal peaks to obtain the best signal-to-noise ratio, in spite of the peak clipping that occurs. The input level at which the modulator begins to code is in general the peak-to-peak amplitude of the comparison signal idling pattern; for inputs smaller than this the coder is undisturbed. The result on the comparison signal of integrating one binary code pulse is known as the delta-step and represents the smallest change in signal amplitude that can be coded.

Referring to Fig. 2 the modulator consists of the transistors X_9 to X_{15} and the associated components. The binary code produced at the collector of X_{15} is fed to the coder integrating network $R_{29}C_{17}$. The integrating capacitor is returned to earth through the output impedance of the emitter-follower X_6 in the c.v.a.; this impedance is sufficiently low for the charging current of C_{17} to produce a change in voltage across it much smaller than the delta-step.

The sum of the audio output of X_6, the comparison signal acros C_{17} and a d.c. level is emitter-followed by X_9 and directly connected to the input of an emitter-coupled slicer X_{10} and X_{11}. The slicer output across R_{32} is emitter-followed by X_{12} and fed into a Schmitt trigger circuit X_{13} and X_{14}; this circuit produces outputs at its collectors which correspond to the input from the slicer but which are of opposite polarity and of a suitable amplitude and d.c. level to be used as steering potentials for the Eccles-Jordan bistable flip-flop X_{15} and X_{16}. The flip-flop is fed with a train of positive going trigger pulses through the capacitors C_{22} and C_{26} and produces the binary code at its collectors. The flip-flop is triggered or not according to its present state and the polarity of the steering potentials produced by the Schmitt trigger circuit. The slicer compares the input to X_9 with the bias potential at the base of X_{11} and according to the sign of the difference voltage the flip-flop is triggered in such a way that the error is reduced during the next digit period. For example, suppose the input to X_9 is more negative than the slicing level, X_{11} is then cut off and the base of X_{12} approaches the supply potential, X_{13} therefore conducts heavily and X_{14} is cut off. The steering potential on MR_6 is then several volts positive with respect to that of MR_5 and a

trigger pulse is fed into the base of X_{16} switching it off and X_{15} on. The next binary code pulse is therefore positive and so reduces the error voltage.

Provided the coder is not slope overloading the method used to add the audio input and comparison signals results in almost constant current charging of the integrating capacitor because the potential of X_9 base only varies by a single delta-step. The time-constant of the integrating circuit has been chosen to produce a delta-step of about 0·4V peak-to-peak; the slicer gain is then sufficient to switch the state of the Schmitt trigger with an input of less than half of the delta-step. Also, the delta-step then covers the slicing range even at high temperatures when due to the change in base current of X_9 the mean level of its input alters.

Binary to Alternating Binary Convertor

The output from the coding circuit, which is a binary pulse code signal, is converted into 'alternating binary' form before being transmitted to the receiver. This form of signal has three equally spaced voltage levels, the centre level corresponding to one binary state and both positive and negative levels corresponding to the other. In this case the negative binary state corresponds to the centre level. In the alternating binary signal consecutive positive binary pulses are transmitted as alternately positive and negative pulses. It is clear that while the binary signal may remain in one state for a number of digits the maximum pulse duration of the alternating binary signal is one digit period. It follows that the low frequency response of transmission circuits required to handle this code can be far worse than if the circuits were to handle binary code. The coder slope overloads on peaks of the audio input and so groups of twenty or so similar pulses in the output are common. The −3dB point in the low frequency response of circuits to handle binary code with groups of twenty similar pulses and produce less than 5 per cent droop would be 5·5 c/s whereas with alternating binary code the corresponding figure is 110c/s. The high frequency response required by both types of signal is the same and so alternating binary provides a saving in bandwidth of over four octaves.

To convert binary code into the alternating binary equivalent, the binary signal is used to gate digit rate pulses into a single stage binary counter. The output of the binary counter is delayed by one digit period, inverted in phase and then added to the original counter output. The result of this addition is the alternating binary signal and this conversion is illustrated by Fig. 5.

The circuit of the convertor is shown in Fig. 2 and consists of the transistors X_{17} to X_{21}. The binary code at the collector of X_{16} is used to steer trigger pulses into the counter. If the binary code is in the more negative state there is a reverse bias on the diodes MR_7 and MR_8 greater than the amplitude of the trigger pulses so that the counter is not triggered. If the binary code is positive, trigger pulses will be fed through MR_7 and MR_8 to trigger the counter which then changes state on every pulse. The operation of the counter is as follows; suppose X_{17} is conducting and X_{18} is cut off the voltage across C_{30} will be several times that across C_{28}, the polarity of the charges being the same and such that the plate connected to the transistor base is the more positive. The trigger pulse is fed to both bases and turns both transistors off. The time-constants of the capacitors C_{28}, C_{30} are long compared with the trigger pulse width so that when the pulse ends the charge on each is unaltered, and since there is less charge on C_{28} than on C_{30} the base of X_{18} will be more negative than the base of X_{17}. The circuit therefore settles down with X_{18} conducting and X_{17} cut off—the opposite condition to that existing before the trigger pulse was applied.

The outputs at the collectors of the binary counter are fed through the steering networks $R_{59}C_{31}$ and $R_{67}C_{35}$ to control the d.c. level of the trigger pulses fed to a similar bistable stage consisting of the transistors X_{19} and X_{20}. The trigger pulses are fed into the base whose steering potential is the more positive. The time-constant of the steering networks is about a third of a digit period so that the d.c. levels of the pulses applied to MR_9 and MR_{10} depend on the state of the binary counter during the previous digit period.

This stage therefore produces outputs identical with the binary counter but delayed by one digit period.

One output is taken from the counter stage and another from the delay stage such that the waveforms are out of phase and these outputs are combined in a resistive adder R_{68}, R_{69} to form the alternating binary code. The output of the resistive adder is emitter-followed by X_{21} into the output transformer T_2 which will produce about 1V peak-to-peak in a 150Ω load.

The Constant Level Amplifier

The voltage slicer circuit in the receiver requires a fixed input level for optimum performance and to provide this constant level an amplifier is used which is nearly identical with the constant volume amplifier already described. In this case the control range required is 30dB and the accuracy and stability of the output level should be ±0·5dB. Since high frequency transistors are used the high frequency response of the constant volume amplifier is more than adequate to handle the alternating binary signal; the low frequency response has been improved by increasing the capacitance of the emitter by-pass capacitors C_5, C_7, C_9 so that the droop produced on the input signal is negligible. The linearity of the constant level amplifier must be better than that of the audio amplifier and so the maximum input applied to the control stage is reduced

The circuit of the constant level amplifier is shown in Fig. 4 and consists of the transistors X_1 to X_8. The form of the circuit is identical with that of the constant volume amplifier except that in this case the input from the transformer T_1 is fed in series with the emitter bias resistor R_2 to avoid using a large coupling capacitor. The reference voltage on the base of the control stage is about 3V to provide the required stability of output level.

The Alternating-Binary to Binary Convertor

The output of the sender unit is an alternating-binary pulse code signal and before it can be decoded it must be converted back into binary code. The received signal may have noise added and its waveform degraded by the transmission path between sender and receiver. The binary code signal used for decoding must consist of pulses of equal duration and amplitude or the signal-to-noise ratio of the audio output will be impaired. The system used in this equipment to regenerate the binary code is to feed the alternating-binary signal at a constant amplitude into voltage slicers which slice the positive and negative pulses and combine them to form a binary output in which, due to noise and degrading of the signal, the pulses may not be integral multiples of the digit period. The slicer output is integrated and then time sampled by digit rate pulses, produced by the receiver timing circuits, which are locked in phase to the incoming signal. The time-sampled binary code is then fed to the decoder and audio amplifier. The receiver timing circuits are locked to the frequency of the input signal by pulses formed by differentiating the slicer output.

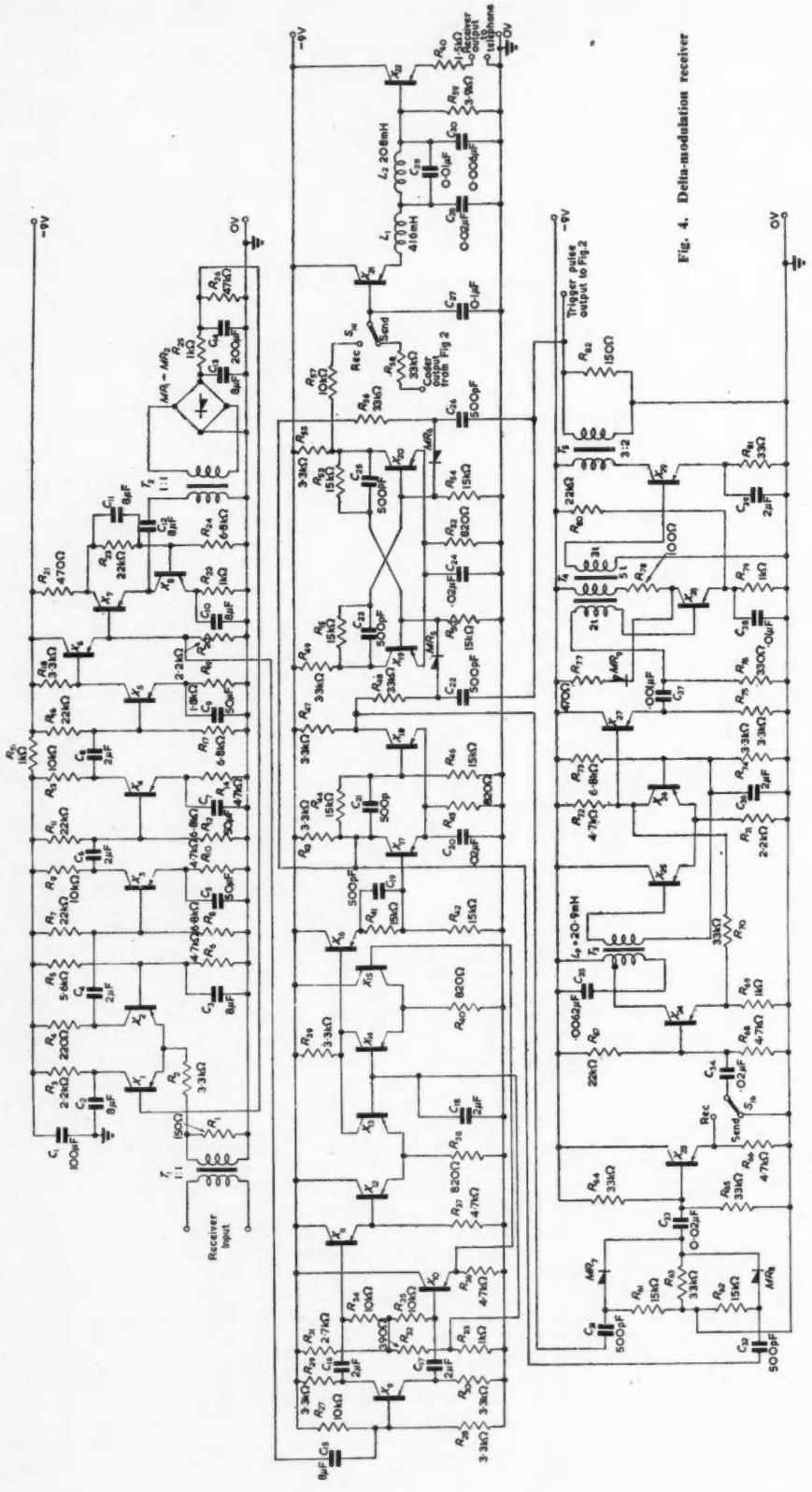

Fig. 4. Delta-modulation receiver

Referring to Fig. 4, the constant level amplifier delivers the received signal at its output at an amplitude of 4V peak-to-peak; this output is fed to a phase-splitting stage X_9, which produces outputs of equal amplitude and opposite phase. Each phase is then emitter-followed to the input of an emitter coupled slicer. Both slicers have the same circuit configuration and component values and have a common output collector load, R_{39}. The bases of the slicer transistors X_{14} and X_{15} are connected together to a point on the potential divider R_{31}, R_{32}, R_{33} which is positive with respect to the d.c. level of the slicer inputs by the voltage drop across R_{32}. The voltage across R_{32} is arranged to be 25 per cent of the peak-to-peak amplitude of the slicer's inputs which are therefore voltage sliced at a point midway between the centre and the more positive levels. Slicing at this point gives the maximum discrimination against noise in the slicer output. The output across the common slicer load R_{39} is the binary equivalent of the slicer input signal since when the centre level is being received neither slicer draws current through R_{39}: at other times one or other of the slicers draws current. It is not possible for both slicers to draw current through R_{39} simultaneously since the signals at their inputs are in anti-phase. The operation of the slicers is illustrated in Fig. 5.

The binary code produced across the slicer's common load resistor is emitter followed into a Schmitt trigger circuit formed by the transistors X_{17} and X_{18}; this circuit gives outputs

across its collector loads corresponding to the binary code but of opposite polarity. The outputs are of suitable amplitude and d.c. level to be used as steering potentials for the time sampling circuit. The receiver timing circuits generate short duration positive-going trigger pulses at the digit frequency which occur about 60 per cent of a digit period after the cross-overs in the binary code output of the voltage slicers. These pulses are fed through the capacitors C_{22} and C_{26} to the diodes MR_5 and MR_6 which are connected to the bases of an Eccles-Jordan bistable flip-flop X_{19} and X_{20}. The d.c. levels of the trigger pulses fed to MR_5 and MR_6 are determined by the Schmitt trigger outputs which are fed through the resistors R_{48} and R_{56}. The amplitude of the trigger pulses is such that they overcome the reverse bias only on the diode whose steering network is connected to the more positive Schmitt trigger output.

The Schmitt trigger therefore controls the trigger pulse input to the flip-flop so that the binary code generated by the sender is accurately reproduced at its collectors. The output of the flip-flop is then fed to the decoding circuit and audio amplifier.

Decoding Circuit and Audio Amplifier

To reproduce the coder comparison signal at the receiver the regenerated binary code is integrated; this signal contains the information fed into the coder and also the quantizing noise component which is produced because the comparison signal is only an approximation of the coder input. The output of the integrating network is fed to the telephone earpiece after passing through a low-pass filter which removes the components of the quantizing noise that lie outside the pass-band of the filter. When the equipment is used to transmit the decoder provides a side-tone signal by decoding the local coder output; this enables a check to be made on the operation of the constant volume amplifier and the coder circuits.

Referring to Fig. 4 the switch S_{1a} selects either the regenerated receiver input or the coder output and feeds the integrating capacitor C_{27}. The level of the sidetone is required to be less than that of the receiver output so the value of the integrating resistor R_{58} used to produce the sidetone is about three times that of R_{57}. The output of the integrator is emitter-followed by X_{21} into the low-pass filter which has a cut-off frequency of 3kc/s and consists of a constant-k section followed by an m-derived section, with an infinite attenuation at 3·5kc/s. The filter is terminated by R_{59} which also provides a d.c. return for the emitter current of X_{21}; the effect of the bias current on the filter coils is to reduce their inductance by less than 1 per cent and can therefore be neglected. An m-derived filter section is used because it is possible for the coder to produce a stable idling pattern of two positive pulses followed by two negative pulses; this pattern has a fundamental component at 3·5kc/s and can cause an unpleasant background whistle. The filtered output is emitter-followed by X_{22} and fed directly to the telephone earpiece which is a low impedance unit and together with R_{60} forms the emitter load of X_{22}.

The Timing Circuits

The digit rate of the sender is determined by the frequency of the train of trigger pulses fed to it and in the receiver a source of trigger pulses locked in phase to the sender output is required to regenerate accurately the transmitted signal. This requires that the digit frequency of the sender should be accurate and stable if the receiver is to have no controls. The sender trigger pulses are generated by a blocking oscillator whose frequency is controlled by a stable LC oscillator. The equipment is a simplex system and so the same oscillator and pulse generator can be used for the receiver if a synchronizing signal is fed in.

The timing circuits are shown in Fig. 4 and consist of the transistors X_{23} to X_{29}. The oscillator circuit[2] is formed by the transistors X_{24} *to* X_{26}. In the sending condition, the capacitor C_{34} is earthed and X_{29} operates as a class-A grounded base amplifier whose output is fed to a tap on

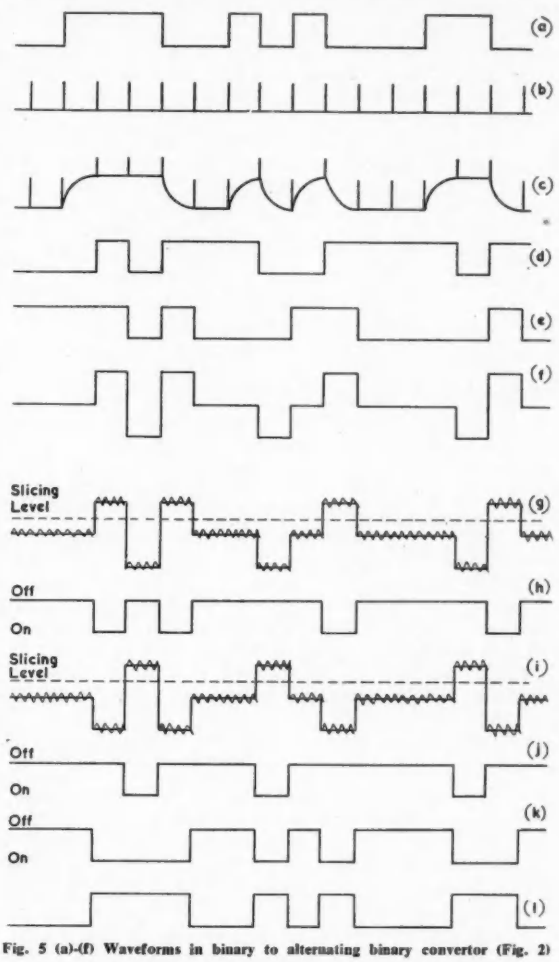

Fig. 5 (a)-(f) Waveforms in binary to alternating binary convertor (Fig. 2)

(g)-(e) Waveforms in alternating binary to binary convertor (Fig. 4)

(a) Coder output from X_{16} (b) Trigger pulses (c) Junction of R_{51} and C_{27} (d) Counter output from X_{17} (e) Delay stage output from X_{20} (f) Alternating binary code at X_{21} (g) Input to base of X_{15} (j) Current in collector of X_{14} (k) Current through R_{29} (l) Binary code across R_{29}

the primary of a tuned transformer T_3. The secondary of the transformer is connected between the bases of an emitter-coupled slicer X_{25} and X_{26}. The output of the slicer if fed back through R_{70} to the emitter of the grounded base amplifier and with the correct connexion of the secondary winding of T_3 oscillations can be maintained in the tuned circuit at an amplitude depending on the feedback current in R_{70}. The value of R_{75} is chosen so that the peak-to-peak input to the slicer is about 2V. Under these conditions the output of the slicer is a square-wave which is very suitable for triggering the blocking oscillator. Also, the mean input impedance of the slicer is high and so does not damp the tuned circuit appreciably. The output impedance of the

grounded base amplifier causes very little damping of the tuned circuit because the collector is fed to a tap on the transformer primary. The frequency is adjusted initially by selecting the value of a small trimming capacitor which is in parallel with C_{35} and thereafter will drift by less than 30c/s as the ambient temperature is varied over the range $-20°C$ to $+60°C$.

The square-wave output of the oscillator is emitter-followed by X_{27} and then differentiated by C_{37} and R_{76}, the negative-going pulses being used to trigger the blocking oscillator, X_{28}. The blocking oscillator is prevented from free-running by the small negative bias on its emitter produced by the potential divider R_{79}, R_{80}. The blocker therefore produces an output pulse for every negative pulse from the differentiating network. The output of the blocker is taken from a winding on the transformer T_4 and fed to a pulse amplifier X_{29} which is driven between cut-off and saturation. The pulse amplitude at the collector of X_{29} is therefore clearly defined and about equal to the supply voltage. The required pulse amplitude is about 2/3 of the supply voltage and so a step down transformer T_5 is used; the transformer secondary is connected to produce positive-going output pulses which are of about 0·5μsec duration at half height. A small negative bias is developed across C_{39} and R_{81} in the emitter of the pulse amplifier to ensure that the stage is thermally stable.

In the receiving condition, the same oscillator and pulse generator circuits are used, but instead of C_{34} being earthed it is connected to the emitter of X_{23} which feeds synchronizing pulses into the oscillator. The outputs of the Schmitt trigger circuit X_{17}, X_{18} are fed to the differentiating networks $C_{31}R_{61}$ and $C_{32}R_{62}$ and the positive going pulses only from each network are fed through the diodes MR_7 and MR_8 to the emitter-follower X_{23}. A positive synchronizing pulse is therefore fed into the oscillator for every cross-over in the binary code output of the voltage slicers. In this equipment the receiver will lock to the sender frequency and regenerate the received signal accurately provided that the difference between the sender frequency and the free running frequency of the receiver does not exceed 1 per cent.

Performance

The system described provides a digitized speech channel of good intelligibility which is extremely simple to operate and will work satisfactorily over a wide range of ambient temperatures. The lower limit of $-20°C$ is fixed by freezing of the electrolyte in the electrolytic capacitors and the upper limit of $+60°C$ is set by the maximum allowable junction temperature of the transistors. No trouble was experienced due to collector leakage currents varying with temperature: high frequency transistors were used throughout.

A power supply of between 6 and 12V is required, the power consumption at 9V being 700mW.

By telephone standards the quality of the audio output from the decoder is very poor, the signal-to-noise ratio being about 14dB. The criterion for this equipment, however, is intelligibility rather than quality and in this respect 14kc/s delta modulation provides almost 100 per cent intelligibility.

The receiver will regenerate the incoming digital signal in spite of noise added in the signal path. In an experiment white noise in the band 0 to 20kc/s was added with an otherwise clean input signal and it was found that with a signal-to-noise ratio of 6·6dB the number of incorrectly regenerated digits was 0·1 per cent.

High stability resistors are used throughout with an initial tolerance of ± 5 per cent. The capacitors used are metallized paper with a tolerance of ± 20 per cent, with the exception of the electrolytics and the oscillator tuning capacitor. (Fig. 4, C_{35}).

Acknowledgment

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A New Research Laboratory

A new research laboratory block, which is part of the Research and Development Division of Tube Investments Ltd, has recently come into full use at Hinxton Hall, near Cambridge.

Other establishments within the Division are a Technological Centre and a Computer Unit at Walsall, and a Department of Technical Information and an Operational Research Unit at Birmingham.

Research work was started at Hinxton Hall in 1954 and was concentrated mainly on solid state physics. With the new building a total area of 35 500ft² has now been provided and facilities include a lecture theatre.

Among the new instruments developed by the laboratory are an X-ray scanning microanalyser and a tube eccentricity meter.

The first prototype microanalyser was developed at the Cavendish Laboratory, Cambridge, but in view of its potentialities in metallurgical research, development at Hinxton Hall was concentrated on exploiting its use in the metallurgical field.

In the Hinxton Hall microanalyser the specimen surface is scanned at slow speed by an electron beam focused to a diameter of less than one micron. X-rays are emitted by the surface atoms when irradiated by this beam, and an analysing crystal is used to select the emission from any chosen element present. This emission is then detected and the signal used to modulate the brightness of a second electron beam scanning a fluorescent screen. Since both beams are scanned in synchronism, a picture is 'painted' on this screen, exhibiting the distribution of the element selected over the area being scanned on the specimen.

This X-ray image can be compared with an electron image formed simultaneously by making use of some of the electrons that bounce back off the specimen. This reflection electron image reveals the surface topography very clearly and is displayed side by side with the X-ray image for comparison. Point quantitative analyses and a linear distribution display are also possible.

An electrical method of measuring tube eccentricity has been developed at Hinxton Hall on which wall thickness variations are assessed by their electrical screening effect.

Transmitting coils inside the tube are electromagnetically excited to produce a field and to induce signals in two external coils placed diametrically opposite. If the wall thickness of the tube being tested varies, its screening effect on the electromagnetic field passing through the tube wall causes a different signal to be developed in the two external coils. This signal can be arranged to indicate as a measure of the wall thickness difference.

Arising out of this work, a sensitive micrometer device has been developed. It also operates on a variation of the electrical screening principle. The instrument can be used for recording small displacements in length measurements (e.g. as in creep testing), as a sensitive position indicator, or as a limit switch where an extremely small movement of the operative part must give reliable operation of the switching circuit. In applying the new device, only a very small attachment need be made to the moving part of the device being studied. Its versatility is such that it can be used to study movements of half an inch or a few millionths of an inch.

A Small, High Voltage, Regulated Power Supply with Variable Output

By J. D. O'Toole*

An increasing field of application exists for high voltage power supplies with stable outputs, without any requirement for large amounts of power. The needs of this field appear to have been imperfectly satisfied due to apparent limitations of available small valves. A basic form of circuit which overcomes the apparent limitations is described, and a typical circuit of this type is given with its performance figures.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

THERE are few small valves which can normally be considered as suitable for the construction of high voltage power supplies with variable output voltages, in the range of one to four kilovolts and current capacity of the order of ten milliamperes. The valves which are available do not immediately make the design of such supplies a straightforward process, because conventional lower voltage circuits require the feedback amplifier valves to have voltage ratings of the same order as the output voltage. A regulating circuit has been devised using the 3D21A (CV2659) beam tetrode as a series regulator and 12AX7 double triodes in the feedback circuit. This basic design reduces the rating requirements and offers a general design approach.

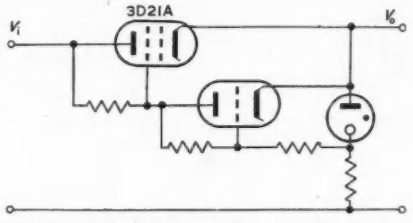


Fig. 1. Shunt stabilized, screen grid supply circuit

Series Regulator

The immediate problem posed by the use of the 3D21A beam tetrode is the low maximum screen grid voltage rating of 850V, compared with the anode voltage rating of 4·5kV maximum under certain conditions of low screen voltage. The use of a second power supply for the screen grid would require this supply to float at the h.t. line potential; because of the insulation requirement, and economy, this arrangement is very undesirable. A simple series resistor in the screen grid supply would not stabilize the grid voltage, because of the large variation of screen current which occurs, and a potentiometer chain across the valve would require an excessively large current to stabilize the screen under all load conditions. An arrangement using a shunt, screen grid, stabilizer circuit, has consequently been chosen. The basic design is shown in Fig. 1, where the triode is the shunt stabilizer, itself stabilized by the gas-filled tube maintaining voltage. The triode anode current at minimum output voltage approximately equals the screen grid current at maximum output voltage and maximum load current. The voltage across the triode remains essentially constant for all load conditions.

Feedback Amplifier

It is easy to see that a triode or pentode amplifier in the feedback circuit, with variable power supply output voltage, controlled by variable amplifier control grid bias, requires approximately 1kV rise of anode voltage for 1kV rise of output voltage. This requires high anode voltage ratings, and therefore special valves, but if a circuit of the type shown in Fig. 2 is used, the large anode voltage swing does not occur. This circuit is basically a cathode coupled, differential amplifier, formed by triodes V_{2a} and V_{2b}, with a high value of fixed cathode resistor R_1 and a variable resistor R_2. Consider the case when $R_2 = 0$; then rise of output voltage V_o as a result of load variation raises the grid voltage of V_{2b}. The anode current rises, but the

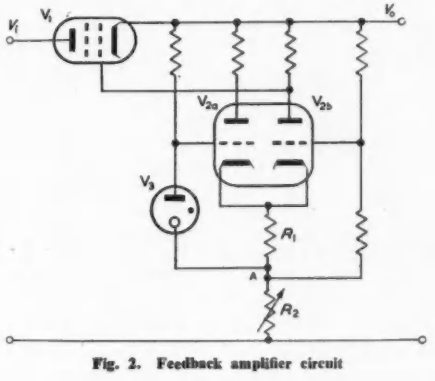


Fig. 2. Feedback amplifier circuit

cathode voltage remains constant, stabilized near the stabilized grid voltage of V_{2a} by a fall of anode current in this valve. The anode voltage of V_{2b} falls and the grid to cathode voltage of V_1 consequently increases negatively, reducing V_o to compensate for its initial change.

Consider next an increase of R_2, raising the potential of point A. The voltage across R_1 remains constant, approximately equal to the stabilizing voltage of V_3, therefore the current through R_1 must remain constant and the cathodes of V_{2a} and V_{2b} must rise in potential by the same amount as point A. A fall of V_{2b} anode current must take place as long as the potential of its grid remains constant; its anode voltage must therefore rise. The grid to cathode voltage of V_1 mnst fall and V_o consequently rises. Equilibrium is restored when the grid to cathode voltage of V_{2b} has returned to its original value, that is when V_o has risen by the same amount as point A. It can be seen that within quite wide limits the triodes V_{2a} and V_{2b} always operate under essentially the same conditions and the amount by which the output voltage may be raised is limited only by the input voltage V_i.

This circuit has incidental features which are noteworthy with regard to output voltage stability at any particular voltage setting:

* *The Plessey Co. Ltd, formerly Standard Telephones and Cables Limited.*

(1) The balanced twin triode arrangement reduces the effects of valve ageing and heater voltage variation.

(2) Current through the stabilizer or reference tube V_3 is constant under all conditions. Changes of the output voltage setting are therefore not followed by slow drift of the output voltage, such as may occur if the current through V_3 is also changed.

3D21A Series Regulator Circuit

The circuit which has been used with the 3D21A is shown in Fig. 3. It is a particular design which gives the following performance:

Input voltage	3·5kV
Output voltage	800V to 2·7kV
Output current as in Fig. 4	16mA at 2·7kV
*Output impedance	25Ω
*Stabilization ratio (small signal)	$1{\cdot}8\ 10^4$

** Output voltage 2·5kV, load current 10mA.*

The feedback amplifier is modified to a cascode circuit, by using one half of the double triode used for regulating the series valve, screen supply. Considerable reduction of output impedance and increase of the stabilization ratio thereby result from the increased gain. There is additionally practically no loss of the characteristics of (1) and (2). The shunt regulator valve V_{4a} is stabilized by the voltage across R_4, which is in turn stabilized by the voltage across V_3. Such an arrangement does not give quite such a well regulated screen supply as would be obtained by using an additional stabilizer valve, as in Fig. 1.

Resistor R_{14} is required to limit the grid current of V_{2a}, during the interval when V_1 has been applied, but V_3 has not ionized, and to ensure that sufficient voltage will be available at the anode of V_3 for ionization to take place. It additionally serves with capacitor C_1 as a filter for stabilizer noise. Capacitor C_2 improves the high frequency response of the feedback amplifier. Capacitor C_3 provides a low impedance return path for signals which appear on the h.t. line, above the amplifier cut-off frequency.

Increased output voltage may be obtained by increasing the applied voltage. It is, however, necessary to realize that, with, say, 4·5kV input and 800V output, a much larger current will be conducted by V_{4a} than when only 3·5kV is applied. In designing this type of supply the current carried by this valve and by the screen grid of V_1 must be carefully considered at the extremes of output voltage. For this purpose the general form of the screen grid and control grid characteristics of the 3D21A are given in Fig. 5.

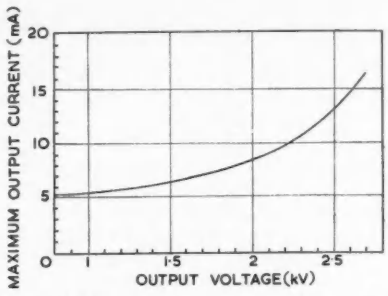


Fig. 4. Maximum output current versus output voltage

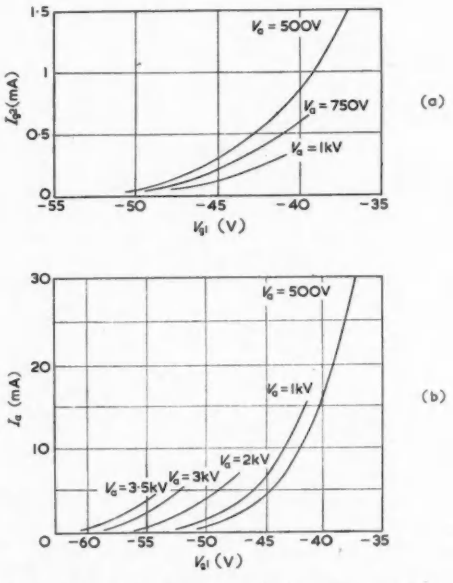
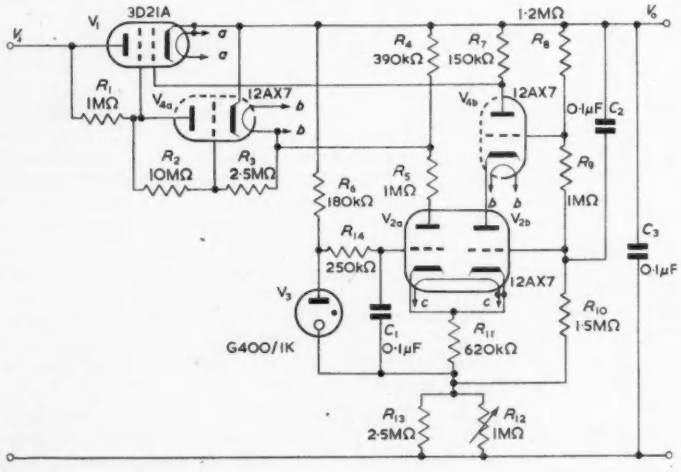


Fig. 5. Screen grid and control grid characteristic of 3D21A. *Screen grid voltage 400V*

Fig. 3. 3D21A series regulator circuit



Delayed switching of V_1 would be advisable with this circuit; it may be obtained by thermal delay devices. It should also be noticed that three heater supplies are indicated, but this requirement may be reduced to two if the trustworthy valve type 6057 is used in place of the equivalent 12AX7 valves.

Conclusion

In conclusion some formulae are given for assessing the performance of this type of power supply. The small signal stabilization ratio of a circuit where the series valve is shunted by a resistor R is:

$$\frac{R}{R + r_a}\ [(r_a/R_L) + \mu\beta A + (r_a/R) + 1]$$

where r_a = series valve anode impedance

μ = series valve amplification factor

βA = feedback amplifier circuit overall gain.

The output impedance is:

$$\frac{r_a}{1 + \mu\beta A}$$

The cascode voltage gain A, using identical triodes is:

$$\frac{\mu' R_L'}{(\mu' + 2)r_a' + R_L'}(\mu' + k + 1)$$

where μ' = feedback amplifier valve amplification factor

r_a' = feedback amplifier valve anode impedance

R_L' = feedback amplifier valve load resistance

For the circuit of Fig. 3, $\beta = \dfrac{R_{10}}{R_8 + R_9 + R_{10}}$

$$k = 1 + R_9/R_{10}$$

Acknowledgments

The author would like to express his thanks to Standard Telephones and Cables Limited, for permission to publish this article.

A Versatile Multi-Frequency Network Analyser

Some five years ago, the Electrical Research Association formulated its plans for a network analyser to be built at its Research Laboratory at Leatherhead, Surrey.

The association has, over a long period, been actively concerned with many studies in electrical engineering such as the flow of harmonics in power systems and rates of rise of restriking voltages and these problems were among the many that were taken into consideration when the design of the analyser was considered. It was recognized too that internal research would not occupy the analyser full time and in order to make the analyser available to individual members of the association a flexible and versatile machine would be required.

An electronic network analyser meeting these requirements has now been constructed and is in full operation.

Its principal parameters are as follows:

Impedance 100Ω (10mH and 1μF)
Power 2·5mW (500mV and 5mA)
Frequency 1·592kc/s (ω 10⁴rad/sec)
Frequency range 0·159 to 15·9kc/s ($\omega = 10^3$ to 10^5rad/sec)

The resolution and repeatability of the measuring equipment is as high as 0·1 per cent of base amplitude and 0·1° of angle for amplitudes greater than 10 per cent.

The impedance and power level chosen results in a signal of 100μV for the metering of a current at 100 per cent level. The desired amplitude resolution calls therefore for a sensitivity of 0·1μV in the current measuring equipment, while the phase resolution requires sensitivity of 0·016μV.

The complete design comprises eight wings of racks housing the network elements which are connected to four interconnecting units or plugboards and the central measuring equipments for the steady state and transient studies respectively which are placed in two control desks at opposite sides of the array. All the network elements are available for use in conjunction with either control desk on large problems.

However, the wings of racks and the plugboards may be suitably apportioned between the two desks, so that studies may be carried out simultaneously on two independent networks, thus giving a high utilization factor for the equipment.

Passive Network Elements

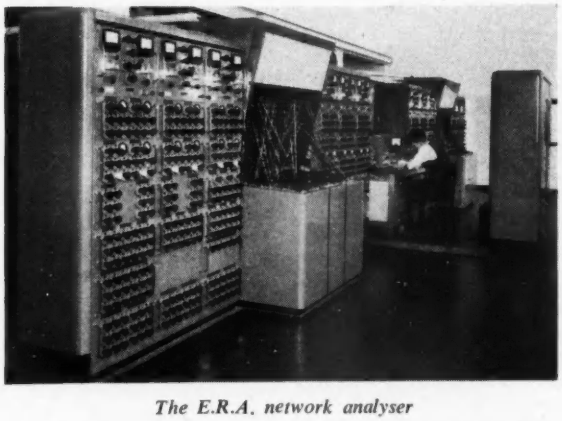
The passive network elements consist of two-terminal elements, composed of decade impedances in simple series or parallel arrangements, and three- or four-terminal elements such as π networks and transformers, together with some electronic amplifiers. The terminals of each two-terminal element are brought out and identified by colour (red or black) at the ends of flexible conductors at a plugboard. Three- or four-terminal units are treated as pairs of two-terminal units. Each unit has also four terminals available for the purpose of metering, i.e., two voltage terminals and two current terminals. The latter are the potential terminals of a 20mΩ shunt incorporated in the read lead of each unit.

Active Network Elements (Generators)

Eighteen generators of a conventional design have been constructed to act as steady state power sources. These 'generators' are in fact adjustable amplifiers, with an independent phase and amplitude control in each unit. The output amplifier, which ensures a low output impedance of 0·1Ω, has its output isolated from earth. Provision has been made for the insertion of built-in adjustable reactances and power and terminal voltage monitors, which will result in a considerable economy of time required to achieve the initial balance in load flow studies.

Central Measuring Equipment for Steady-State Studies

The main measuring system consists of three automatic a.c. potentiometers operating simultaneously to indicate the potential difference V (amplitude and phase) between the selected points in the network, the current I through the selected unit (amplitude and phase), the direct phase difference ϕ between V and I and the products $VI \cos\phi$ and $VI \sin\phi$. The last give the active and reactive load (watts P and V Ars Q) when V and I refer to voltage across and current through a unit or network. An independent direct voltmeter is also provided, mainly for the purpose of quick checks and for monitoring a voltage across one unit while adjustments may be made to other units.



The E.R.A. network analyser

The reference signal for the bridge measurement is derived from the same three-phase master oscillator that provides excitation for the generator units. The measurement of voltage (or current) is made by comparing the selected voltage signal from the network nodes (or from a shunt) with a reference signal derived from a potentiometer. The difference of these two voltages operates a servo-system which adjusts the slider position on the potentiometer and the phase of the signal supplied to the potentiometer until a balance is obtained.

The shafts of the potentiometers and phase shifters are coupled to dials on the control desk so that their angular positions display current and voltage in amplitude and in phase relative to a reference signal, together with the phase-angle between them.

The measurement of active and reactive load, which is usually difficult in variable frequency systems, has been made fairly easy by the use of an analogue method. The multiplying operations required are performed on a fixed frequency analogue signal by means of potentiometers and a sine-cosine resolver ganged with the voltage and current bridges. The accuracy of these operations is governed by the linearity of the amplitude potentiometers (which is 0·1 per cent) and the accuracy of the sine-cosine potentiometer which may introduce errors of 0·2 per cent.

The direct measurement of voltage is made by means of an amplifier-operated rectifier instrument. Amplitude only is measured, but phase-angle may be indicated on one of the monitoring cathode-ray tubes. Three such tubes are provided for permanent display of voltage waveforms at important points in the measuring system which can be selected at will, thus facilitating adjustment and giving indication of faults.

A System for Providing a Precise Vector Voltage

By D. J. Collins*, B.Sc., A.M.I.E.E., and J. E. Smith*, B.Sc.

In many fields of electronics there is often a requirement to produce a voltage of known phase and amplitude relative to some reference level. If one neglects electro-mechanical devices, the accuracy to which this can be done is largely dependent upon the accuracies of the components of the phase shifter. The article deals with a possible system for producing a precise vector voltage which can be of any amplitude less than reference and of a phase relationship between 0° and 360°. Such a system is of great use in the calibration of phase shifters and phase measuring devices.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

IN the development of phase measuring equipment, it is quite often necessary to obtain a sinusoidal voltage of precisely known amplitude and phase relative to an initial reference voltage.

This can be done without undue difficulty, if it is required only at one precisely known frequency. However, if the voltage is required at a frequency not precisely known or over a band of frequencies, the problem is more difficult. The system detailed in this article indicates a method of tackling the problem over quite a wide frequency range.

The system consists of two stages. In the first stage, four vector voltages are established with phase relationships of 0°, 90°, 180° and 270°. The second stage utilizes these four vector voltages to select the precise vector voltage required.

Reference Vector Voltages

The basic reference voltage at the required frequency is conveniently obtained from a laboratory oscillator. It is necessary for the oscillator to provide a voltage with low distortion and adequate stability. A secondary requirement is that the voltage level shall be greater than the amplitude of the required voltage. This second requirement is not of prime importance, since the oscillator output can be suitably amplified. For the purpose of description it will be accepted that a 10V r.m.s. level is adequate, and this basic 10V reference will be termed the 0° phase.

The system now requires the generation of other reference vectors, but these are limited to vectors of 10V amplitude at the other cardinal points, i.e. 90°, 180° and 270°.

The 180° phase presents no problem, and at this level a simple image or -1 amplifier (previously described[1]) can be used. The quadrature phases are not so easily obtained, particularly if the frequency is not accurately known or a range of frequencies have to be covered. In this system, the basic integrator is used to provide the 90° phase. The circuit is shown schematically in Fig. 1, and it can be proved that if the gain M is greater than 10^3 and if $R \sim X_c$ at the chosen frequency, the angular error is of the order of 0·1°. If $R = X_c$, then the amplitude transmission is unity.

Fig. 2 shows how, by the use of the two operators units -1 and j, any pair of adjacent cardinal points may be derived from the 0° phase.

Vector Selection

Each cardinal pair embraces a quadrant and, for a certain vector requirement, the reference voltage configuration which covers the appropriate quadrant should be chosen. For convenience of analysis, it is assumed that the 0° to 90° quadrant is selected. There are thus available two reference voltages, E and jE where $E = 10$. Consider these voltages applied to a resistance network as shown in Fig. 3, and let the output voltage E_o be the required vector $A\angle\phi$.

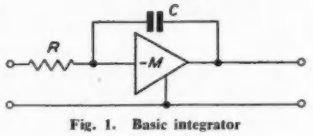


Fig. 1. Basic integrator

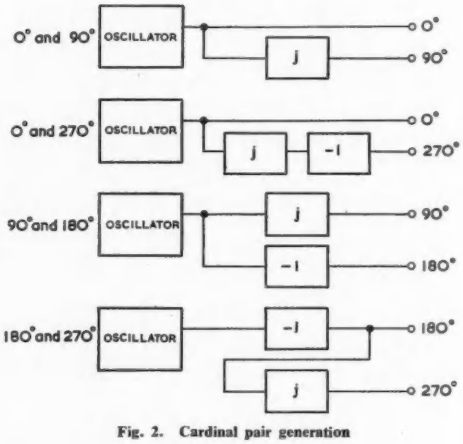


Fig. 2. Cardinal pair generation

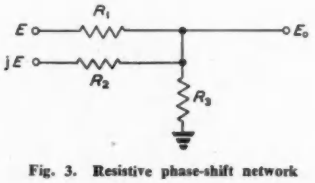


Fig. 3. Resistive phase-shift network

It can be shown that

$$A = \frac{R_3\sqrt{(R_1^2+R_2^2)}}{R_1R_2+R_1R_3+R_2R_3} \text{ and } \varphi = \tan^{-1} R_1/R_2$$

Thus by suitable choice of the three resistor values, the desired vector can be obtained, and it is obvious that the vector parameters are unaffected over a wide frequency range.

Since it is likely that some load may be applied to this

* Solartron Research & Development Ltd.

vector source, a buffer amplifier can be interposed and R_3 can conveniently form the input resistance of the amplifier. R_1 and R_2 are then more suitable as decade resistance boxes.

The resistive phase shifter of Fig 3 can be utilized in more convenient form by arranging calculated networks at, say, 10° steps, and selecting the required network by a uniselector system coupled to a digital indicator. Use is made of this resistive phase shifter in the commercial instrument shown in Fig. 4.

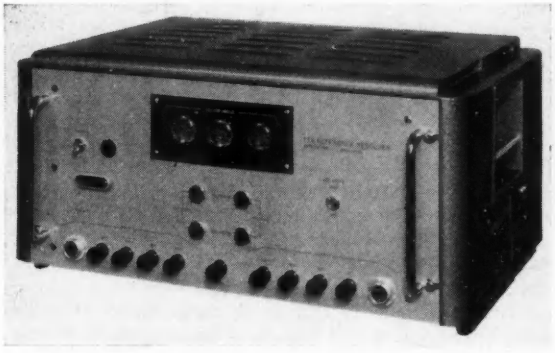


Fig. 4. Instrument for utilizing the phase-shift network of Fig. 3.

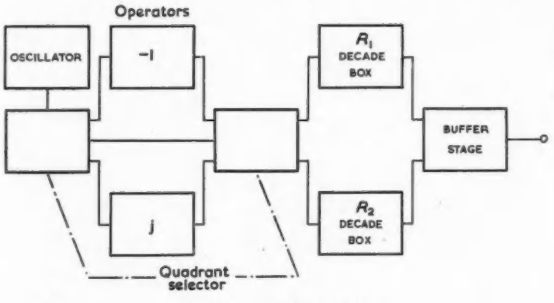


Fig. 5. A complete system

Practical Considerations

A complete system is shown schematically in Fig. 5, and a system of this type has been used in the laboratory to cover a frequency range of 1c/s to 1kc/s. With modification, it would be possible to extend the frequency range in both directions.

The oscillator, apart from having the required voltage output, should also be capable of driving the system load without increase in distortion. Its output impedance will be required to be low, usually less than 10Ω.

The '−1' operator amplifier should have reasonably high input impedance, at least 10kΩ, and again an output impedance of less than 10Ω. It should have negligible phase error, less than 0·1°, over the frequency range required, and should be capable of handling the basic voltage level. Its gain should be capable of slight adjustment about the unity condition.

The 'j' operator integrator should have the same order of input and output impedance as the '−1' unit. Its phase error can be made less than 0·1°, but its amplitude transmission is only unity if $R = X_c$. To maintain this condition over a wide frequency range will require a change of the value of C and possibly variations in R. It is thus convenient, when operating over a wide frequency range, to select spot frequencies and switch suitable CR values for these frequencies. An important point to note is that the integrator is liable to have a long term d.c. level drift due to grid current, and it may be necessary to include a 're-set' switch to discharge the capacitor.

The quadrant selector is merely a switch system which selects the appropriate vectors, and it may be convenient to incorporate on this switch monitor points at which the basic amplitude can be set. The level can be set by using an a.c./d.c. digital voltmeter and adjusting the oscillator output and the fine controls on the operator units. The reference voltage vectors will thus be obtainable at an amplitude accuracy of the order of 0·1 per cent and an angular accuracy of better than 0·2°.

The voltage selector system, comprising the decade boxes R_1 and R_2 and the buffer amplifier, will satisfy most requirements, but it may be more convenient to choose resistor pairs for R_1, R_2 at selected angles. In addition, at high frequencies, variation of stray capacitances in the decade boxes will rule them out. The buffer amplifier will be required to have negligible phase error, in addition to its dynamic characteristics. The voltage selection system, assuming a perfect reference input, can have errors less than 0·1 per cent amplitude and 0·1° angularity.

In the laboratory, it has been possible to produce, with this type of system, vectors to a phase accuracy of 0·2° and 0·2 per cent amplitude accuracy.

Acknowledgment

The authors wish to record their thanks to the Directors of Solartron Research & Development Ltd for permission to publish this article.

Appendix

(a) A Limited Check of Integrator Error

A phase-sensitive voltmeter can be used in the following manner to indicate any large error in the angular accuracy of the integrator.

Using the 0° phase as reference, the 90° phase as signal, it is possible from the meter indications to calculate an error angle ϕ_1. Then reversing the connexions, using the 90° phase as reference, the 0° phase as signal, a new error angle ϕ_2 is calculated.

The integrator error is then $\frac{1}{2}(\phi_1 + \phi_2)$

If the voltmeter has no error, ϕ_1 will equal ϕ_2. If, however, it has error, the magnitude is given by:—

$$\tfrac{1}{2}(\phi_1 - \phi_2)$$

This method, however, can only give indication of error if it exceeds 0·5°. It can only be used to ensure that there has been no gross error in the design or construction of the integrator.

(b) Use of the Integrator as a 'Backing Off' Source

Reference 1 describes a method of using a phase sensitive voltmeter to measure small errors in nominal 0° and 180° phase relationships. It utilizes a −1 or image amplifier as a source of 'backing off' voltage. The integrator provides a source of quadrature 'backing off' which can be used in measuring errors in nominal 90° and 270° phases by the same method.

By the same token, if it were possible to derive from the basic 0° phase a 270° phase to an accuracy of, say, 0·01°, the system could be used for checking the integrator itself!

References

1. Collins, D. J., Smith, J. E. Measurement of Small Phase Shifts with a Phase Sensitive Voltmeter. *Electronic Engng. 30*, 146 (1958).
2. Collins, D. J., Smith, J. E. Some Methods of Phase Measurement used in Transfer Function Analysis. *Electronic Engng. 30*, 182 (1958).

An Alternative Method for Comparing the Electrical Properties of Epoxy Casting Resins

By D. H. Thompson*

This article describes a method of assessing the dielectric constant, loss, and volume resistivity of epoxy casting resins over a wide temperature range and for frequencies up to 5Mc/s.

This coverage is achieved at the expense of reduced absolute accuracy when compared with the standard method of Hartshorn and Ward; however, when primarily used for comparison of resins and assessing the temperature stability of their electrical parameters, the method described here merits more widespread use.

In particular, absolute values may be quoted from this method provided care is taken to verify or normalize the results at laboratory temperature.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

It will be common experience in the electronic and electrical industry that the specialized information relating to the electrical properties of epoxy casting resins is seldom available from the manufacturers. This is understandable since the variety and nature of measurements ultimately required do not fall within the scope of resin manufacturers. Thus, it is felt that the details of methods developed for the speedy accumulation of electrical data, may be of interest to others in the electronic industry.

The problem arose of selecting an epoxy resin-filler combination possessing particularly stable electrical characteristics for a circuit encapsulation application. The selection of a suitable system involved measurements of a range of 60 resin-filler-hardener systems.

Two methods were available, one based on that of Hartshorn and Ward, utilizing a jig supplied by Marconi Instruments Ltd for use with their TF329G circuit magnification X meter (Q meter); the other, to use resin cast trimmers as test-pieces and the same Q meter.

Discussion of Merits of Available Apparatus

The Marconi jig was not readily adaptable or suitable for use at other than laboratory temperature, a disadvantage common to its parent method; difficulty also exists in allowing for edge effects.

The method using cast trimmers may be applied with care over a wide temperature range. In fact, some resins have been tested from $-60°C$ to $+140°C$ by this method. The edge effects are no longer serious but some doubt exists concerning any strains set up by the contraction of the resin during cure, which may leave the trimmer somewhat distorted, or the resin stressed. It was known that very high pressures tend to increase the dielectric constant of dielectrics; however, an initial survey showed such effects, if present, to be small in the test sample and errors in excess of one or two per cent. unlikely.

Preparation of Trimmer

Certain precautions were necessary in the preparation of the jig; these are best described in detail. A 100pF air dielectric, ceramic mounted, pre-set trimmer capacitor was used (Fig. 1(a)).

Stiff leads of 20 s.w.g. tinned copper wire were soldered to the free lug of the rotor and to one of the solder 'blobs' retaining the stator. To prevent surface effects, sleeves of high resistivity were placed over these leads to extend about 1cm beyond the centre boss of the capacitor (Fig. 1(b)). P.T.F.E. was used, as this material has high resistivity (volume resistivity approximately $10^{20}\,\Omega$-cm), low surface contamination and can withstand high temperatures. The capacitor was next degreased with re-distilled carbon tetrachloride and dried, finally, at 105°C.

Prior to the casting, the capacitor was hung by its leads in a suitable mould, typically a 2in diameter impact extruded aluminium can prepared with a release agent, and resin poured in to a level just covering the boss. Entrapped air was removed by placing the mould in a vacuum chamber and reducing the pressure to approximately 0·1mm Hg. Vacuum filling is, of course, to be preferred. The method cited here is intended to simplify apparatus requirements and is satisfactory if sufficient care is taken. After curing to the manufacturer's schedule and removing from the mould, a hole $\frac{1}{16}$in diameter was drilled $\frac{1}{2}$in deep, axially, in the boss of the trimmer, to accept a thermocouple junction (Fig. 1(c)).

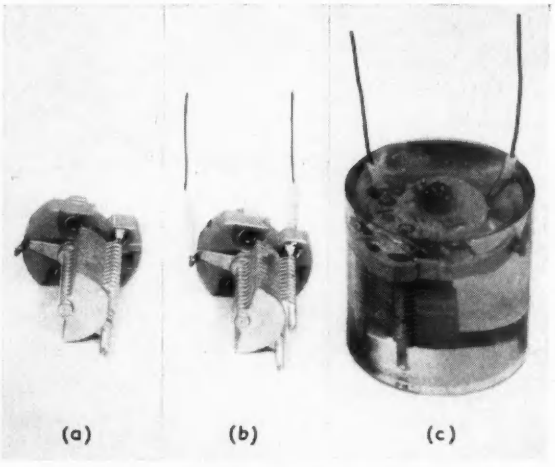


Fig. 1. Dielectric trimmer used for the measurement of electrical properties of epoxy resin systems

(a) As received
(b) Showing p.t.f.e. sleeved leads
(c) Potted in unfilled epoxy resin systems

Method of Using Trimmer

It is necessary to modify a suitable, thermostatically controlled, oven such that p.t.f.e. bushes are fitted through its walls to allow the capacitor leads to pass directly to a Q meter. These leads must be of the absolute minimum length, and must be standardized.

* *E.M.I. Electronics Ltd.*

With the capacitor thus mounted and using either the standard Marconi inductors or laboratory versions made to tune to desired frequencies, the capacitance of the jig may now be measured at any temperature within the range covered by the oven. Provided the rotor of the potted capacitor is connected to the Q meter 'earthy' capacitance terminal, the thermocouple may be left in situ when readings are taken.

A small, low temperature, housing was made to contain the specimen in a close-fitting can surrounded by a mixture of ethane diol, methylated spirits, and solid carbon dioxide. It is important to maintain the same lead length as before.

The method of measuring the capacitance with a Q meter is as described in the instruction manual, but above 2Mc/s calibration by substitution was necessary. The dielectric loss of the capacitor may be found directly, in terms of shunt resistances, by direct substitution. It is only necessary to plot graphs of Q against shunt resistance for each frequency used, and of capacitance against the capacitance dial setting for each frequency above 2Mc/s. Direct substitution is not necessary for each operation.

For measurements at higher frequencies only, the use of a smaller trimmer would be advisable.

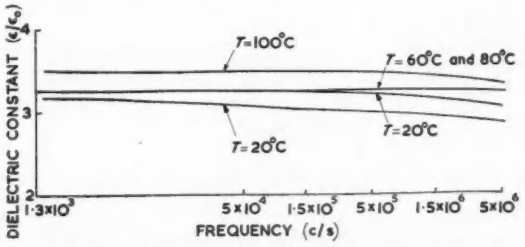


Fig. 2. Variation of dielectric constant with frequency and temperature for an amine-cured epoxy resin system

The capacitance was measured at audio frequency using a capacitance bridge; the resistance was measured at 500V d.c. The Cintel, wide-range bridge proved suitable in this application. Both measurements are straightforward but the use of p.t.f.e. insulation and a guard system for the ohmmeter is advisable.

Interpretation of Results

The dielectric constant K is given by :—

$$K = C_2/C_1$$

where C_1 = capacitance of unpotted trimmer.

C_2 = capacitance of potted trimmer.

The volume resistivity ρ_{dc} is given by :—

$$\rho_{dc} = C_1 R/\varepsilon_0$$

C_1 = capacitance in farads.

R = resistance of the trimmer in ohms.

$\varepsilon_0 = 1/36\ \pi \times 10^{-9}$ farads/metre.

ρ_{dc} = volume resistivity in ohm-meters

The above equation can be used to obtain a parameter which is the a.c. volume resistivity at pulsatance ω and which may be used to derive stray shunt resistances, e.g., given by the expression

$$R = \varepsilon_0 \rho \omega / C$$

The above equation expresses the shunt resistance introduced when a unit having a stray capacitance of C farads (measured before potting) is potted, provided this stray capacitance were in air. Thus, in general, a high value of $\rho\omega$ is preferable to a low loss tangent as the latter is also a function of K for the resin.

Accuracy

The accuracy will not be considered here in detail, but estimates made have shown the probable error not to exceed ± 5 per cent for dielectric constant and ± 10 per cent for volume resistivity. Typical electrical characteristics of an epoxy resin system measured by the techniques described are shown in Figs. 2 and 3.

Conclusion

This method of using trimmers has been successfully employed to evaluate sixty resin systems. These results have been compared to those obtained using the Marconi jig mentioned, with satisfactory agreement.

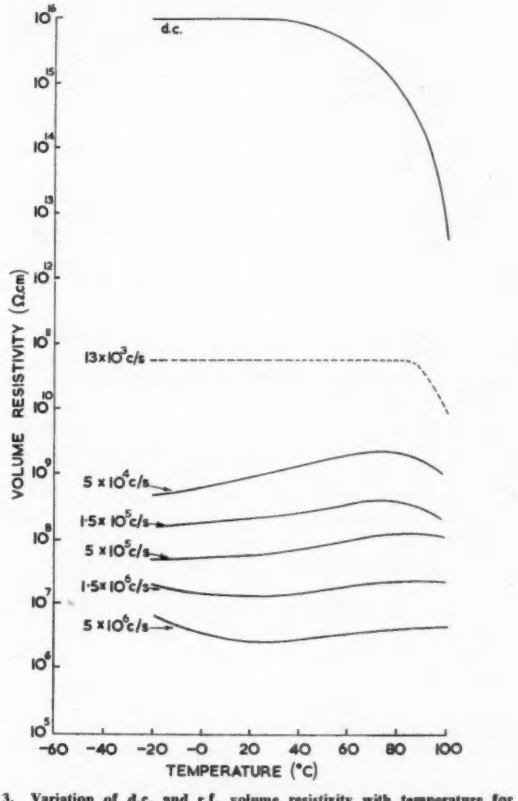


Fig. 3. Variation of d.c. and r.f. volume resistivity with temperature for amine-cured epoxy resin system

This jig is not original but it is not widely known and when known, its accuracy is suspected. The justification for this article is to attempt to remove some of this suspicion and establish the validity of the method for practical industrial purposes when comparative results are of primary importance. In these circumstances, this method can be used to save labour and obtain results more speedily than the standard method.

Acknowledgment

Thanks are due to the heads of departments involved and Company officials for permission and encouragement in publishing this article.

A Transistorized L.T. Regulator

By J. H. Deichen*

The methods of providing a stabilized d.c. supply for valve heaters are examined and their limitations are discussed. A simple circuit using a transistor and two Zener diodes is then given and its design and performance described.

(Voir page 707 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 712)

FOR a specific problem in hand, it was necessary to regulate the heater voltage of a signal generator oscillator valve and of a d.c. amplifier for an automatic level control circuit. The two valves were rated at 400mA and 200mA at 6·3V respectively. A number of previously published circuits were investigated but most of them were found to be deficient in one way or another.

The constant voltage transformer is undesirable as it is frequency conscious and too bulky to fit into a portable instrument.

The back-to-back Zener diode method as described by Kezer and Aronson[1] regulates only the peak voltage and not the r.m.s. value. It is only effective if a large part of the waveform is cut off, thus giving low efficiency. Like the single Zener diode for regulating d.c. as described by Pereli[2] the regulation is only effective for relatively small currents. Any large variations in the Zener diode current alters the diode voltage. Therefore, for good regulation, the current variation must be small and the impedance of the load must be large compared with the effective resistance of the diode.

The transductor[3,4] has the disadvantage of being bulky and heavy and is unsuitable for installing into small instruments. It is a constant average current device and to achieve constant r.m.s. regulation a compensating unregulated supply must be available for part of the control voltage, and this supply must not be derived from a source supplying a varying load. R.M.S. stability could not be achieved by the smoothing method described by Smith[5] as the input capacitor of the filter would charge to the peak voltage, which becomes greater with mains increase due to the peak current waveform of the a.c. fed to the rectifiers. Stability could, however, be obtained by a choke input filter but the choke must be very large so that its impedance is high compared to the output capacitor impedance. The large choke renders the system unsuitable for the application under discussion. A further disadvantage of the transductor when feeding more than one valve is that, being a current regulator, if one valve fails or is removed the other valve or valves are forced to take higher current.

A method investigated by the author was the use of a multivibrator, the output of which was fed via a centre-tapped, step down transformer to a rectifier and a smoothing circuit and thence to the heaters of the valves to be regulated. The stability proved to be very good but all the heater load plus the losses were derived from a stabilized high tension supply. This, of course, rendered the system expensive as a large high tension regulator was required and the multivibrator valve took a heater current as great as the regulated low tension required.

Transistorized Regulator

The transistorized regulator which has a similar circuit arrangement to the conventional high tension regulator but without a d.c. amplifier stage was investigated and adapted for the instrument in question. The circuit is, in fact, an emitter-follower and is shown in Fig. 3. The principle of operation can best be shown by starting with the circuit of Fig. 1. As this is a cathode-follower its cathode voltage is largely independent of the applied anode voltage. The regulation is dependent upon the output impedance for load variation and upon the gain for variations in input voltage. The improvement in voltage variation against input change for this circuit is not sufficient

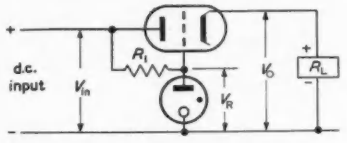


Fig. 1. A simple valve regulator

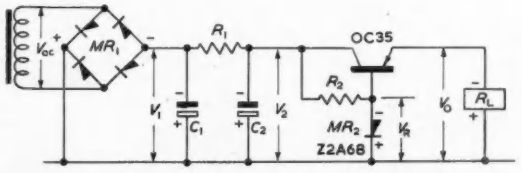


Fig. 2. A complete transistorized regulator, 10 to 1 improvement

for most applications. Therefore, to lower the effective output impedance and to increase the gain of the system a d.c. amplifier is added between the reference neon and the valve grid. The circuit shown in Fig. 2 is an equivalent circuit using a transistor and Zener diode instead of the valve and neon. The theory of this circuit is given by Brown and Stephenson[5] and is similar to the cathode-follower, but unlike the cathode-follower it caters for low voltage and high current. Very often for low tension supplies the degree of regulation can be lower than for high tension and, therefore, a d.c. amplifier is not necessary. The circuit in Fig. 2 does, in fact, give a 10 to 1 voltage change improvement at 600mA for 6·3V heaters. Referring to Fig. 2 the resistor, R_2, is designed to supply the correct nominal current through the Zener diode, MR_2, and for this particular design the nominal current was set at 25mA. The base-emitter current of approximately 15mA is also obtained via resistor R_2. Components C_1, C_2, and R_1 constitute the smoothing circuit for the bridge rectifier MR_1. The hum level obtained was less than 5mV r.m.s. and the power dissipated in the transistor was less than 3W at nominal input voltage.

To obtain greater stability a d.c. amplifier can be added between the Zener diode and the transistor base. However, a somewhat easier method, although with not as great an improvement in stability, is the use of two Zener diodes in cascade as shown in Fig. 3. The stability of a regulator depends on the stability of the reference voltage and, in fact, using the circuit of Fig. 2, the reference voltage does

* *Marconi Instruments Ltd.*

alter with mains voltage change due to the large change in current through the reference diode. The circuit in Fig. 3 uses a second Zener diode, MR_3, to regulate the current through MR_2. This circuit gives a voltage improvement of 30 to 1. Referring to Fig. 3, the components C_1, C_2 and R_3 constitute the smoothing circuit, giving a hum level of less than 1mV r.m.s. across the load, R_L. The value of resistor R_3 is selected to give a nominal current of 35mA through diode MR_3. As stated before, the load consisted of two valve heaters, one taking 400mA and the other 200mA. Removing the 400mA valve the voltage across the other rose by 0·1V. On the other hand, by making a 20 per cent increase in load the voltage dropped by 0·05V. It was found that the voltage drop between the base and emitter of the transistor was 0·3V, therefore the load voltage is 0·3 less than the reference. Using a 5 per cent tolerance reference diode of 6·8V nominal the load voltage will lie between 6·16 and 6·84. For many valve heaters this tolerance is permissible, therefore an adjustment for voltage level is not necessary. If a closer value must be obtained then a suitable resistor can be added in series with the

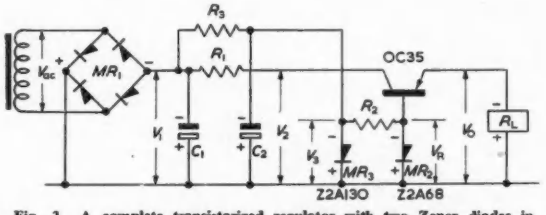


Fig. 3. A complete transistorized regulator with two Zener diodes in cascade, 30 to 1 improvement

heaters. The circuit does not provide for temperature compensation and does, in fact, vary by about +0·15 per cent/°C rise. The temperature coefficient of the Zener diode used is given at +0·04 per cent/°C, but by using two lower voltage diodes in series a negative coefficient of approximately −0·06 per cent/°C is realized. Therefore the temperature coefficient of the circuit would be approximately +0·05 per cent/°C rise.

Design Considerations

The design considerations are very simple, the most important being to not exceed the transistor dissipation. If greater load current is desired the transistor can be substituted by one of greater rating and they can, of course, be used in parallel. The collector voltage must be sufficiently high for regulation down to the lowest input visualized and the author found a value of 4·5 to 5V above the emitter voltage to be sufficient for ±10 per cent change in mains voltage. For obtaining the resistor values for Fig. 3 the following formulae apply:

$$R_1 = \frac{V_1 - V_2}{I_L}$$

where I_L is the load current.

$$R_2 = \frac{V_3 - V_R}{i_R + i_{be}}$$

where i_R is the nominal current through the reference diode and i_{be} is the base-emitter current.

$$R_3 = \frac{V_1 - V_3}{i_3 + i_R + i_{be}}$$

where i_3 is the normal current through the Zener diode MR_3.

The calculation of resistor values for Fig. 2 is similar.

Component and voltage values for Fig. 3 are as follows:

V_{ac}—15V r.m.s.	R_1—8·5Ω
V_1—16·5V	R_2—150Ω
V_2—11·5V	R_3—33Ω
V_3—13V ±5 per cent	C_1—1 000μF
V_4—6·8V ±5 per cent	C_2—500μF
V_o—6·5V ±5 per cent	

It should be noted the polarity is normally negative with respect to earth.

Acknowledgments

The author wishes to thank the management of Marconi Instruments Ltd. for permission to publish this article and to Mr. J. Golding for his helpful suggestions.

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Extensions to Nucleonic Instrument Factory

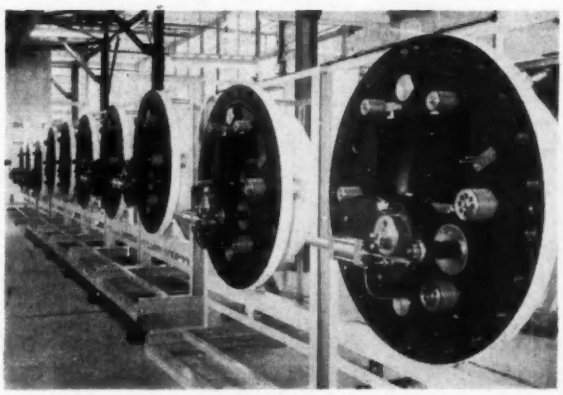
The extensions opened recently by Sir John Cockcroft have nearly doubled the factory area of Plessey Nucleonics Ltd of Northampton.

The main programme of the Company has been the development of a system for the detection of failures in fuel element cans in the reactors of nuclear power stations. To this range of burst slug detection equipment has been added flux scanning equipment, radiation detectors, process control and health instrumentation.

The Company's Burst Slug Detectors were installed at Calder Hall and Chapelcross and improved types are now being assembled for installation at Hinkley Point and elsewhere.

Among the new instruments developed at Northampton is a low energy gamma ray monitor which has application as a replacement for alpha monitors for the detection and location of fissile materials such as ^{239}Pu and ^{235}U. Other radiation monitors include types developed for food, milk and water monitoring

Ten burst slug detection precipitator units, manufactured by Plessey Nucleonics Limited for the nuclear power station at Hinkley Point, here being assembled in the clean area (dust free) of the Northampton factory.



THERMOELECTRIC COOLING*

RECENT developments in thermoelectric cooling are the results of applying new semiconductor materials, evolved in studies of solid state physics, to certain principles discovered in the classical physics of the early nineteenth century.

Seebeck observed, in 1821, that a potential difference develops when the junction of two dissimilar conductors is heated. He misunderstood the meaning of his results, but his arrangement of materials in a thermoelectric series is substantially the same as that recognized today.

A second thermoelectric effect was discovered by Peltier in 1834. He showed that heat is absorbed or generated when a current passes across the junction between two dissimilar conductors, and the direction of flow of the current determines whether the junction becomes cold or hot. This effect is distinct from the normal Joule resistive heating effect, but is superimposed upon it. Again the results were misinterpreted and it was thought that Joule's law did not apply when the current was small.

Thomson (later Lord Kelvin) sought to define a relationship between the Seebeck and Peltier effects in terms of thermodynamic theory. He concluded that a third thermoelectric effect existed and that there is heating or cooling in a single conductor, along which there is a temperature gradient, when a current is passed through it. This is known as the Thomson effect.

In 1838 Lenz succeeded in freezing water by passing current through a bismuth antimony junction, the ice being melted when the current was reversed. It is possible that the success of his experiment owed something to the fact that it was carried out in the low ambient temperature of a St. Petersburg winter.

Very little practical application was found for these discoveries but the Seebeck effect has long been used in thermocouples for temperature measurement and in thermopiles for radiation detection. In both these applications. high sensitivity compensates for low efficiency but, until recently, even inefficient thermoelectric refrigeration based on the Peltier effect was impossible with the materials then available.

However, a basic theory of thermoelectric refrigeration was derived by Altenkirch in 1911. He was able to express the coefficient of performance in terms of a figure of merit calculated from the thermal e.m.f. coefficient and the thermal and electrical conductivities of the materials of the thermocouple. Practical refrigeration was not possible. however, until the new semiconductor thermocouples became available in very recent years.

Theory

It can be shown[1] that the maximum value of the performance ϕ is

$$\phi_{max} = \frac{T(\sqrt{(1+\theta^2)}-1)}{\Delta T(\sqrt{(1+\theta^2)}+1)} - \tfrac{1}{2} \quad \ldots\ldots\ldots (1)$$

where ΔT is the temperature difference $(T_H - T_C)$ between the hot and cold junctions
T is the mean temperature, $\frac{1}{2}(T_H + T_C)$
and ϕ is the figure of merit of the thermocouple, given by

$$\phi = \frac{(\alpha_p - \alpha_n)T^{\frac{1}{2}}}{(\kappa_p/\sigma_p)^{\frac{1}{2}} + (\kappa_n/\sigma_n)^{\frac{1}{2}}} \quad \ldots\ldots\ldots\ldots (2)$$

and α is the thermal e.m.f. coefficient
κ represents thermal conductivity
σ represents electrical conductivity
and the subscripts p and n refer to the positive and negative elements of the thermocouple, which must have absolute thermal e.m.f. coefficients of opposite sign.

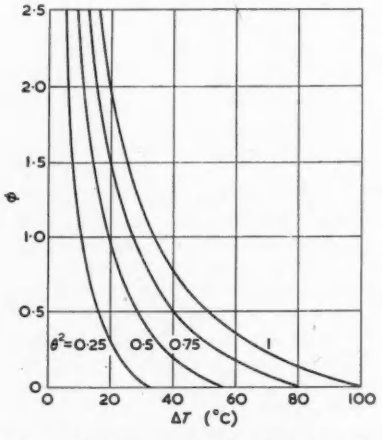


Fig. 1. Coefficient of performance plotted against temperature difference for a mean temperature of 290°K

As $\theta \to \infty$, ϕ tends to $(T - \frac{1}{2}\Delta T)/\Delta T$ which is the coefficient of performance of an ideal thermodynamic machine. By setting $\phi_{max} = 0$ the maximum temperature difference may be found from

$$\frac{\Delta T_{max}}{T} = 2\,\frac{\sqrt{(1+\theta^2)}-1}{\sqrt{(1+\theta^2)}+1} \quad \ldots\ldots\ldots\ldots (3)$$

Fig. 1 shows the variation of the coefficient of performance with temperature difference for various values of figure of merit. In Fig. 2 the maximum temperature difference is shown plotted against the figure of merit.

When the temperature difference is appreciable, considerable variations of α, σ and κ occur over the length of the couple. It is found to be desirable in making calculations to use the mean values of these three quantities over the range of temperature concerned.

Cascade arrangements of thermocouples may be used to obtain greater differences of cooling than are possible with a single stage. The first stage is then used to provide a cold sink for the hot junctions of a second stage, which

* *Communication from the G.E.C. Research Laboratories, Wembley.*

may, in similar fashion, provide an even colder sink for a third stage, and so on. For practical reasons it is considered advisable to limit the arrangement to two stages.

Semiconductor Thermocouples[2]

Equation (1) shows the high values of θ, the figure of merit, are required in the application of thermoelectric refrigeration, and Fig. 1 indicates that values of θ approaching unity are essential. In equation (2) it would be more convenient to have separate values of θ defined for each element in terms of

$$\theta_p = \alpha_p \sqrt{(\sigma_p T/\kappa_p)}$$
$$\theta_n = -\alpha_n \sqrt{(\sigma_n T/\kappa_n)}$$

If σ/κ is the same for each element, then θ is the arithmetic mean of θ_p and θ_n, and this is effectively true for the best thermocouples. The ratio σ/κ is substantially the same for all metals at a given temperature and the best choice for thermoelectric applications are those with the highest values of thermal e.m.f. coefficient. Such combinations are found among the alloys of bismuth and antimony. In semiconductors the ratio σ/κ is usually much smaller than for metals but this apparent disadvantage, from the thermoelectric point of view, is often more than counterbalanced by a very much higher value of thermal e.m.f. coefficient, which may well rise to millivolts per °C instead of units or tens of microvolts per °C for metals.

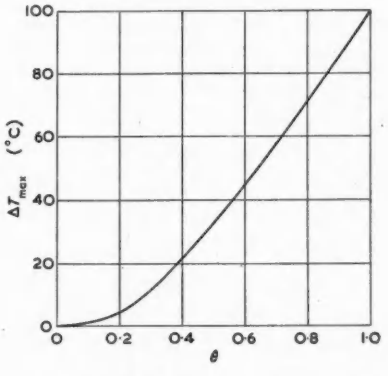


Fig. 2. Maximum temperature difference plotted against figure of merit at a mean temperature of 290°K

Thermoelectric coefficients in semiconductors are high when the carrier concentration is low and low when the carrier concentration, and therefore the electrical conductivity, is high. There is thus a conflict between the requirements, for a high figure of merit θ, that both the thermal e.m.f. coefficient and the electrical conductivity should be high. Both these characteristics can be modified by varying the concentration of impurities in the semiconductor, and the optimum value of θ is obtained when the thermal e.m.f. coefficients are about $\pm 200\mu V/°C$. The figure of merit depends upon other factors which are capable of a degree of control, such as carrier mobility and the effective mass of the charge carriers, but prediction of the value of the functional combination of all the factors which defines the end result is complicated and difficult. In a given series of semiconductors, however, such as the Group IV elements, diamond, silicon and germanium, or the intermetallic compounds of Groups III and V, it is found that improvement in thermoelectric performance generally goes with rising atomic weight. The best compound semiconductors developed so far for thermoelectric applications are lead telluride and bismuth telluride, both formed from elements of high atomic weight. The best thermocouple combination of this type found so far is formed from p-type and n-type bismuth telluride, Bi_2Te_3, with an overall figure of merit θ of 0·76 and giving, at a mean temperature of 290°K (17°C), a maximum temperature difference obtained by Peltier cooling of 65°C.

If, however, the semiconductor compound is alloyed with an isomorphous material the thermal conductivity of the alloy may be reduced with no change in the carrier mobility, or at least only a relatively small reduction in this parameter. Such alloying may therefore improve the thermoelectric properties of the material. It has been found possible to form solid solutions between bismuth and antimony tellurides (Bi_2Te_3 and Sb_2Te_3), bismuth selenide (Bi_2Se_3) or bismuth sulphide (Bi_2S_3). Some of the best combinations of the resulting alloys made in the Research Laboratories of The General Electric Company at Wembley have given an overall figure of merit of 0·86 and a maximum temperature difference of 80°C at a mean temperature of 17°C. The improved results followed a reduction of thermal conductivity with no substantial change in the electrical conductivity or thermal e.m.f. coefficient.

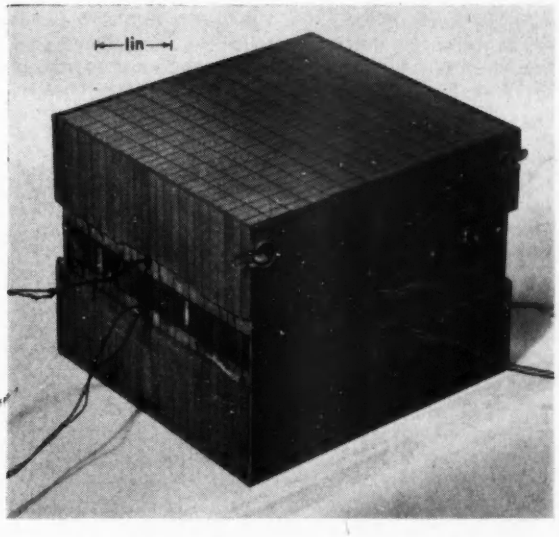


Fig. 3. Thermocouple elements soldered together and assembled in units

Although the preparation of thermoelectric semiconductor materials is simpler than that of the preparation of semiconductors for transistors, the control of composition of the compounds, and alloys of compounds, required does present difficulties. Nevertheless, polycrystalline material is acceptable rather than the single crystals necessary for producing transistors and the impurity requirements are less stringent by a factor of 10^4 or 10^5. The thermocouple elements, cut from ingots or sintered from powder pressings, are soldered together and assembled in units such as those illustrated in Fig. 3.

Practical Applications

Although a temperature difference of 80°C is possible with the best semiconductor thermocouples it is achieved

only when the unit is doing no work. When operating with reasonable efficiency, differences of temperature across the thermocouple of some 30 to 50°C are obtained. The efficiency of operation increases with smaller temperature differences and decreases as the difference of temperature is made larger.

When the thermocouple is used to cool the air in an enclosure further temperature gradients are set up between the thermoelectric junction and the air. The drop in air temperature which can be achieved then becomes 20 to 30°C. If a greater degree of cooling is required a second stage thermoelectric unit must be added. This will need to have a greater capacity and loading than the first stage.

A single thermocouple designed to work with a moderate direct current, in the range 5 to 10A, has a cooling power limited to about ¼W. Cooling units of many watts capacity are made from a large number of thermocouples, usually mounted side by side and connected electrically in series. The thermoelectric cooling principle offers the facility of designing proportionally smaller units down to very low levels of cooling power.

The use of thermoelectric cooling for domestic refrigeration is an obvious possibility which offers the advantages of silent operation and avoidance of the use of chemical refrigerants, but requires a small rectifier/transformer unit to furnish the direct current. The exploration of this potential application is receiving very careful study, in which technical problems and technical performance are being assessed alongside true economics. Note has to be taken of the very high degree of economy in manufacture which the conventional refrigerator industry has achieved.

There are many fields of instrumentation and engineering in which thermoelectric refrigeration appears to offer more opportunities. Instruments which have already been developed and described include an automatic dew point hygrometer, a cooled baffle for an oil-diffusion vacuum pump and a thermostat for electronic equipment. There are many interesting possibilities opened up in the prospect of being able to maintain control units, for example oscillator crystals, at stabilized temperatures below ambient. The power handling capacity of transistors and other components may be increased if local cooling by thermoelectric means can be applied.

Other possible applications of thermoelectric cooling arise in the fields of medicine and biology. Its use in surgery is perhaps somewhat problematical because the space available for the insertion of a cooling unit in the patient during an operation is limited and the amount of heat which must be extracted, for example to cool down arteries, is much larger than would at first sight be expected—the human body is remarkably effective in its power to maintain a flow of heat to a locally chilled area. There is a possible use for cooling measuring equipment and microtomes, where constant low temperature is important, and for cold-storing specimens in the portable equipment in which they are conveyed, for example, from the operating theatre to the pathology laboratory. A thermoelectric cool chest would be an excellent solution to the problem of storing biotics and antibiotics in hospitals and in doctors' surgeries.

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A New Data Processing System

The English Electric Company has placed on the market a new data processing system, known as the KDP.10, which is believed to be the most comprehensive and up-to-date system available anywhere in the world today.

The experience gained from the application of 'Deuce' to specific sectors of the commercial data processing field led the company to undertake intensive studies to find the ideal form which such data processing systems could take.

The new data processing system which is to be built at the company's Kidsgrove works, is based on a design by the Radio Corporation of America, modified to suit manufacturing techniques and operational requirements in the United Kingdom and Europe.

It is a complete and fully transistorized data processing system embodying the latest techniques of advanced computer design and is capable of handling alpha-numeric data and employs magnetic tape, punched paper tape and punched card input-output as well as printed output. These facilities allow the system to be integrated with any existing mechanized office and, by the use of magnetic tape, provide for the daily scrutiny and up-dating of records and files in organizations handling masses of detailed information.

Its magnetic core storage is expandable to provide for a very large capacity and its outstanding characteristics include an extremely high rate of transfer of information to and from the magnetic tape storage. The system can record and transfer information on tape at a speed of 33 333 characters/second in the quantity required—unlike the conventional systems which provide for standard lengths of tape whatever the amount recorded.

The KDP.10 system consists of a number of integrated units covering high speed store, programme control unit, tape selection and buffer unit and a console with associated monitor printers and paper tape punch, a paper tape reader and high speed printers.

The high speed store is a random access magnetic core device which provides storage for programmes and data. This memory can be easily expanded to meet system requirements within the range of 16 000/260 000 characters.

A tape selection and buffer unit *A* allows for the connexion of from one to eight tape stations to the computer and controls reading from and writing to magnetic tape on these stations. Programme instructions indicate the appropriate magnetic tape unit for input or output. It is important to note that the number of magnetic tape units directly controlled by the computer may be increased to 62 by connecting the tape selection unit *B* to each of the lines of unit *A*.

Paper tape punch and tape verifiers are used for the original preparation and verification of the system coded 7-hole punched paper tape operating at a rate of 1 000 characters per second for subsequent input into the computer.

The main output is from a high speed line printer operating under the control of the computer and producing up to six copies at 600 lines per minute; each line may have up to 120 characters.

Included in the peripheral equipment complementary to KDP.10 are a card transcriber, transcribing card punch, tape reader verifier and random access file. It is important to note here that in many cases it is convenient to use punched cards for input and output data; off-line card/magnetic tape and magnetic tape/card convertors operating at 400 and 150 cards/minute respectively are available.

The system is readily adaptable to meet the requirements of both small and large organizations; for a smaller concern, wishing to allow for future growth, the KDP.10 can be built up, unit by unit in proportion to the volume of work demanded of it without altering the basic installation.

Short News Items

Premiums for Technical Writing. The scheme for awarding annual premiums for articles on electronics, organized in the past by the Radio Industry Council is now under the joint sponsorship of the Council and the Electronic Engineering Association. Articles published in 1959 will be considered by the panel of judges early in the New Year. Six premiums of 25 guineas each are offered to writers not earning their living wholly or mainly by writing. The judges, headed by Professor H. E. M. Barlow, Professor of Electrical Engineering, University College, London, are given the greatest possible freedom in deciding which articles merit awards, but they principally take into consideration the value of the article in making known British achievements in radio and electronics, originality of subject, technical interest, presentation and clarity. Writers are reminded that articles for consideration should be in the hands of the Secretary of The Electronic Engineering Association, 11 Green Street, Mayfair, London, W.1, before the end of the year. Eight copies of the journal or relevant pages, proofs or reprints with a signed declaration of the eligibility of the writer or writers should be submitted. This latter ruling does not apply to authors of articles published in the following journals as the members of the panel of judges automatically receive copies of these: British Communications and Electronics; Electronic Engineering; Electronic and Radio Engineer; The Post Office Electrical Engineers Journal; Radio Constructor; Wireless World.

'Lead the Enduring Metal' is the title of a film recently produced by the Lead Development Association. The film, which may be borrowed from the Association, has a running time of 28min and describes the production and uses of lead. It is interesting to note that the cable making industry accounts for about one-third of this country's consumption of this metal.

The British Radio Valve Manufacturers' Association announces that in the near future it will hand over to a new Association, the Electronic Valve and Semi-Conductor Manufacturers' Association (VASCA), its responsibilities for semiconductors and industrial valves and tubes. The B.V.A. will continue its separate interest in domestic valves and television tubes. Founder members of the new Association are: English Electric Valve Co. Ltd; M.O. Valve Co. Ltd/General Electric Co. Ltd; Mullard Ltd; Siemens Edison Swan Ltd/British Thomson-Houston Co. Ltd; Standard Telephones & Cables Ltd. Sections, virtually autonomous, will deal separately with: (i) Transmitting, including microwave, valves. (ii) Semiconductors, including rectifiers up to (rating to be defined by the Section). (iii) Industrial receiving valves. (iv) Gas-filled devices. (v) Industrial cathode-ray tubes, photo-electric and photo-sensitive devices. Among the objects of VASCA are the provision of facilities for discussion and co-operation among members; promotion of standardization; encouragement of and participation in research and experimental engineering work and tests; co-operation with the Government, the Services, B.S.I., I.E.C. and I.E.E.; maintenance of a high standard of quality, design and workmanship; dissemination of information to members; compilation and dissemination of statistics; and the promotion of exports. The Secretary of VASCA is Mr. W. R. West, the Chairman, Mr. G. A. Marriott, and the offices are at Piccadilly House, 16 Jermyn Street, London, S.W.1.

Willesden and Hendon Productivity Committee are organizing a Conference to be held at the Headquarters of the F.B.I. at 21 Tothill Street, Westminster, London, S.W.1, on 27 January, 1960. Both large and small organizations should find the Conference of interest to all levels of management as well as people concerned with purchasing. The chairman will be Mr. M. Seaman who is Director and General Manager of British Oxygen Engineering Co. Admission fee will be two guineas. Requests for details and reservations, together with remittance, should be sent to Mr. D. I. Duncan, A.E.I. Switchgear Division, 20 Neasden Lane, Willesden, London, N.W.10.

The first comprehensive all-British Exhibition and Trade Fair to be held in the U.S.A. will be held at the Coliseum Exhibition Building, New York, in June 1960. It has the full backing of the British Government, The Dollar Exports Council, the Federation of British Industries and the British-American Chamber of Commerce in New York and is being organized by British Overseas Fairs Ltd (B.O.F.). The main aim of the Exhibition is to increase the sales of British goods in the U.S.A. and also to publicize and boost the prestige of Britain and British Industry throughout the North American continent. A New York Liaison Committee, under the Chairmanship of Sir Alexander Brackenridge, K.B.E., M.C., meets regularly in New York and is in continuous contact with the organizers and a similar Liaison Committee in London. Further particulars can be obtained on application to British Overseas Fairs Ltd, 21 Tothill Street, London, S.W.1.

The International Congress on Microwave Valves will be held in Munich from 7 to 11 June 1960. Papers may be read in German, English or French. Contributors are invited to write for further particulars to: Vortragsausschuss der Internationalen Tagung, Mikrowellenröhren, z. Hd. Herrn Prof. Dr. W. Kleen, München 8, Balanstrasse 73.

The Cambridge Instrument Co. Ltd have opened new research laboratories at Chesterton Road, Cambridge; the opening ceremony being performed by the Rt. Hon. the Lord Adrian, O.M., F.R.S., on 14 October. The main laboratory block consists of four flours approximately 100ft long and 40ft wide. Each floor has a separate function and the experimental or working area of each is laid out on an 'open vista' plan. On the ground floor is the Mechanical Engineering Laboratory and a constant temperature room. The first floor is devoted to Physics and Electronics while the second floor houses the Physical Chemistry Laboratory. The top floor is occupied by the Design and Drawing Office. It is anticipated that these new research facilities coupled with increased production facilities will provide a broader base and materially increase the Company's capacity to meet the requirements of science and industry.

E.M.I. Electronics Ltd have received an order from the Ministry of Pensions and National Insurance for an all-transistor EMIDEC 2400 computer, costing over half a million pounds to manufacture and install. The computing centre will be set up at the Ministry's Newcastle establishment to deal with the huge volume of data processing connected with the new Graduated Pensions Scheme. It has been calculated that there are some 25 000 000 insured persons, with over a million additions or changes each year. The computer will 'store' full statistics such as name and address, amount of each contribution and sum paid to date, of each insured person. Each day, the records of every insured man and woman in the United Kingdom will be processed in order to extract the required information for persons reaching retirement age, and other changes in personal particulars. The computer is capable of completing this task in under four hours. The number of forms which will have to be processed yearly to enable the scheme to operate at top efficiency will total over 30 000 000. Another EMIDEC 2400 to be delivered will be for the Royal Army Ordnance Corps. This will maintain full records of the Army's stocks of motor transport spares, the compilation of accounts for the stores, and the calculation of requirements for stock replenishment and the control of stock levels.

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Cell Effect in Capacitors

DEAR SIR,—During recent experiments with transistor d.c. amplifiers a puzzling drift was found to be due to a relatively pronounced cell effect existing in a 3 000μF 6V electrolytic capacitor. The capacitor, which was used to reduce short term fluctuations in input current to the circuit, showed a reluctance to follow changes in circuit voltage and acted like a cell which required charging or discharging before static conditions could be obtained.

Although most engineers are familiar with the cell effect, it may not be generally known that capacitor manufacturers have determined its cause and evolved methods of reducing it to negligible proportions.

Slight impurities in the aluminium electrodes are responsible for the effect, and making both electrodes from the same piece of material is a great help. If cell effect is already present in a capacitor, it may be reduced by shorting the electrodes for about 3 weeks. A combination of a common electrode material and shorting out will produce the best results.

Yours faithfully,

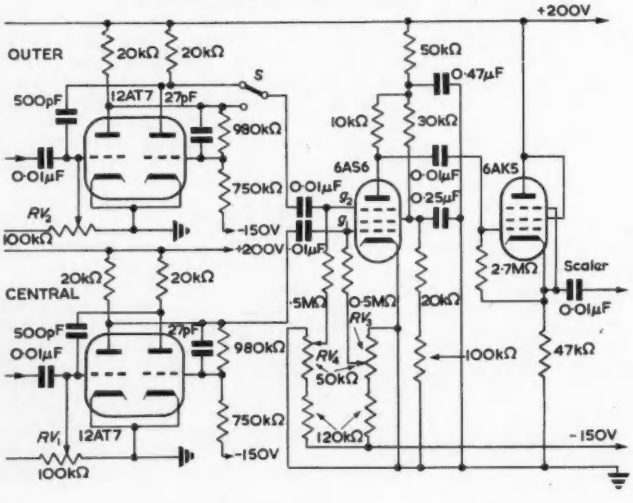
P. K. TOMKINS,
Nucleonics Laboratory,
Burndept Limited, Erith.

A Simple Anti-Coincidence or Coincidence Circuit

DEAR SIR,—A simple circuit, which can function as an anti-coincidence or a coincidence circuit whenever desired, was constructed using a 6AS6 valve. The 6AS6 is a pentode having two control grids, and is suitable for fast signal operation. The input pulses to the two grids were made square by 12AT7 double-triodes functioning as univibrators. The output pulse from the 6AS6 was fed to a 6AK5 cathode-follower, and subsequently it can be fed to a binary scaling circuit. This arrangement has been used in operating a gas-flow G.M. counter in anti-coincidence with a ring of cosmic ray guard-counters for low level tracer work*.

Fig. 1 shows the circuit diagram. The left-hand sides of the 12AT7's are conducting, negative pulses are fed to the first grids of the two valves, and square pulses, whose width can be adjusted with the potentiometers RV_1 and RV_2, develop at the anodes. Normally the 6AS6, having an anode potential of 180V, is not conducting as a negative bias is applied to both the grids and this can be adjusted from 0 to 25V by the potentiometers RV_3 and RV_4. For the anti-coincidence arrangement the grid g_1 is given a -20V bias and receives the positive square pulses from the line of the central counter, while the grid g_2 is given zero bias and receives the negative square pulses, suitably widened, from the line of the outer guard-counters. The pulses from the guard-counters only and also the simultaneous pulses from the central and one of the guard-counters will not be recorded, whereas, pulses from the central counter only will give sharp negative output pulses. For the coincidence arrangement the grid bias g_2 is changed to -15V and fed with the positive output pulses from the univibrator by changing the position of the switch *S*. The final output pulses can be registered by a suitable scaler and recorder.

Fig. 1. The anti-coincidence-coincidence circuit



The author wishes to express his thanks to Prof. B. D. Nag for suggesting the problem.

Yours faithfully,

F. HOSAIN,
Saha Institute of Nuclear Physics,
Calcutta 9.

REFERENCE

* HOSAIN, F. *Naturwissenschaften 45*, 107 (1958).

Current Creep in Transistors

DEAR SIR,—Mr. R. E. George, who reports (ELECTRONIC ENGINEERING, March 1959) on an approximately exponential drift in transistor I_{co}, may be interested to compare my experience of an unaccountable drift in oscillator frequency using certain specimens of transistor. It was reported in *Wireless World*, September 1957, p. 443-4 (see also October, p. 487).

This frequency drift, presumably due to individual transistor characteristics, for some other samples showed no signs of it, also had an approximately exponential characteristic with a time-constant of the order of hours. Similarly, the possibility of a thermal origin had been ruled out because of the low power and long time-constant. Unlike the effect reported by Mr. George, however, the drift continued for a short while after switching off, and the transistors concerned took at least several hours to return to their original state. The makers were unable to shed any light on the affair.

If Mr. George would like further details I would be happy to oblige.

Yours faithfully,

M. G. SCROGGIE,
Bromley, Kent.

Current "Creep" in Transistors

DEAR SIR,—The slow growth of reverse current through pn junctions reported by Mr. R. E. George (ELECTRONIC ENGINEERING, March 1959) is similar to the effects reported previously by Plummer[1]. In these experiments slow growths of current were produced by the adsorption of moisture on the surface of a semiconductor diode. In a series of measurements on pn junction diodes under controlled humidity, we[2] established that the slow growth of current and the $1/f$ noise were closely connected with the adsorbed water on the surface of the diodes. With very low humidity, both of these effects disappeared. Therefore it seemed probable that an explanation of the slow growth of current would also include an explanation of the noise spectrum.

We proposed a model in which the water film was insulated from the semiconductor by an oxide layer and separation of ions in the water film would occur when a voltage was applied across the junction. The separated ions would diffuse across the surface of the oxide layer generating electrostatically a surface 'channel' of the type discussed by Brown[3], and the slow extension of this channel would account for the growth of current. The diffusion constants of ions ($\sim 10^{-5}$ cm^2 sec^{-1}) are of the correct order to account for the long growth times. In this model, current would not flow through the water film and electrolysis would not occur[4].

An analysis of the current fluctuations, produced by fluctuations of the density of diffusing surface ions, which modulated the resistance of a surface channel, was made using the method described by Richardson[5], and the spectrum obtained varied as $1/f^{1.5}$. The measured exponent was $-1{\cdot}25$.

Measurements made by Law[6] of the adsorption characteristics of germanium oxide surfaces indicate that the problem of completely excluding water from a transistor is formidable. Present manufacturing technique makes use of the adsorption of a few monolayers of water to reduce the surface recombination velocity in pnp transistors and thereby to increase the current gain. In applications where low frequency noise and current 'creep' become troublesome, it may be worth sacrificing some current gain by rigorously excluding adsorbed water, and it would be interesting to hear the opinion of transistor manufacturers on this point.

Yours faithfully,

J. E. PALLETT,
University of Edinburgh,
Department of Engineering.

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4. ERIKSEN, W. T., STATZ, H., DEMARS, G. A. Excess Surface Currents on Germanium and Silicon Diodes. *J. appl. Phys. 28*, 133 (1957).
5. RICHARDSON, J. M. The Linear Theory of Fluctuations Arising from Diffusional Mechanisms —An Attempt at a Theory of Contact Noise. *Bell Syst. Tech. J. 29*, 117 (1950).
6. LAW, J. T. The Absorption of Gases on a Germanium Surface. *J. Phys. Chem. USSR. 59*, 543 (1955).

The Correspondent Replies:

DEAR SIR,—Following my letter[1], my attention has been drawn[2] to a paper by Plummer[3] who reported the slow increase of reverse current across a germanium pn junction as attributable to water contamination. Although the rate of increase of current in the presence of the electric field across the junction was very slow, he found that on removal of the field, the effect had almost disappeared in one second. This creep phenomenon is confirmed by Mr. Pallett in his recent letter, who also finds it associated with excessive flicker noise. During measurements on transistor noise, I have noticed that some of the transistor types producing excessive noise tended to show current creep, but no systematic measurements were undertaken to establish this.

While carrying out simple routine checks on a batch of r.f. transistors, I had already discovered one with creep in I_{co} checked at 4·5V as described previously. I tried this sample in Mr. Scroggie's circuit[4]. Over a period of 28min, the frequency decreased by 0·1 per cent, while the current drawn increased by 30 per cent. The dissipation did not exceed 9mW. In order to test whether there was any relation between frequency drift and creep, the current drawn was reduced to its original value by increasing the base feed resistance. Other transistors of the same type under the same conditions showed far less drift than the specimen showing creep. It would appear therefore that the two effects might be related.

There can be no doubt that transistor manufacturers are aware of this problem. One manufacturer is already marketing low noise transistors, which I have found to be comparatively free from creep.

Yours faithfully,

R. E. GEORGE,
Electronics Section,
Physics Department,
Guy's Hospital Medical School,
London.

REFERENCES

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2. ROBERTS, F. F. Private Communication.
3. PLUMMER, A. R. F. Observations on the Growth of Excess Current in Germanium p-n Junctions. *Proc. Phys. Soc. 69B*, 539 (1956).
4. SCROGGIE, M. G. Transistor oscillator Stability. *Wireless World 63*, 444 (Fig. 2(b)) (1957).

Transistor Circuit Temperature Stability Analyses

DEAR SIR,—In a recent letter by Ryan[1] he indicated that the frequency selective amplifier he described achieved bias stabilization by means of negative feedback. The amplifier shown in Fig. 1 is

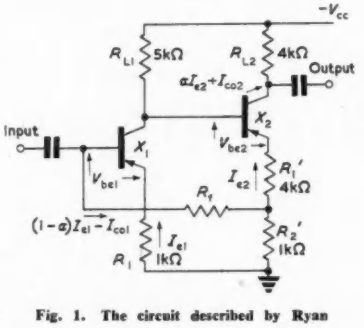

Fig. 1. The circuit described by Ryan

the configuration described by Ryan, where R_f was a twin-T filter. The actual stability of this or any other transistor circuit can be predicted by an analytical procedure as follows.

Let any bias parameter be a function of the main temperature dependent terms in the circuit. For this example assume the base-emitter voltage (V_{be}) and the reverse saturation collector-base current (I_{co}) cause the main temperature instability. Assume the temperature variations of I_{e_2} is of interest, then.

$$I_{e_2} = f(V_{be_1},\ V_{be_2},\ I_{co_1},\ I_{co_2} \ldots\ldots \quad (1)$$

By differentiating equation (1) with respect to temperature:

$$dI_{e_2}/dT = \partial I_{e_2}/\partial V_{be_1} \cdot dV_{be_1}/dT + \partial I_{e_2}/\partial V_{be_2} \cdot dV_{be_2}/dT + \partial I_{e_2}/\partial I_{co_1} \cdot dI_{co_1}/dT + \partial I_{e_2}/\partial_{co_2} \cdot dI_{co_2}/dI \ldots \quad (2)$$

Assuming

$$dV_{be_1}/dT = dV_{be_2}/dT \text{ and } dI_{co_1}/dT = dI_{co_2}/dT$$

then equation (2) can be written;

$$dI_{e_2}/dT = \left[\frac{\partial I_{e_2}}{\partial V_{be_1}} + \frac{\partial I_{e_2}}{\partial V_{be_2}}\right] dV_{be}/dT + \left[\frac{\partial I_{e_2}}{\partial I_{co_1}} + \frac{\partial I_{e_2}}{\partial I_{co_2}}\right] dI_{co}/dT \quad (3)$$

The partial differential terms enclosed in brackets depend on the circuit configuration and can be found by taking suitable mesh equations and differentiating with respect to each of the temperature dependent terms.

Defining

$$D_v = \partial I_{e_2}/\partial V_{be_1} + \partial I_{e_2}/\partial V_{be_2} \ldots \quad (4)$$

and

$$D_i = \partial I_{e_2}/\partial I_{co_1} + \partial I_{e_2}/\partial I_{co_2} \ldots\ldots \quad (5)$$

it follows simply (although somewhat tediously) that:

$$D_v = R_{1_1} - R_1/D_c \ldots\ldots\ldots \quad (6)$$

$$D_i = R_{1_1}(R_f+R_1) + R_1R_1'/D_c \ldots \quad (7)$$

where

$$D_c = R_1(R_1'+R_2')+R_1'R_{1_1}$$

Using circuit values as indicated in Fig. 1 and assuming (from experimental observations) that V_{be} varies linearly at $-0{\cdot}002$V/°C and I_{co} at any temperature is given approximately by 7·03 exp $(-8400/T)$ for alloy junction low power pnp transistors), it follows that:

$$D_v = -0{\cdot}004$$

$$D_i = 0{\cdot}6$$

and by integrating equation (3)

$$I_{e_2}(T_2) = I_{e_2}(T_1) + 0{\cdot}004 \times 0{\cdot}002[T_1 - T_2] + 0{\cdot}6[I_{co}(T_1) - I_{co}(T_0)] \ldots\ldots\ldots \quad (8)$$

Assuming $T_1 = 65$°C and $T_0 = 20$°C, the predicted shift in I_{e_2} is 0·1mA. This is in excellent agreement with experimental observations.

Yours faithfully,

B. A. BOWEN,
University of Syracuse,
Syracuse, N.Y.

REFERENCE

1. RYAN, W. D. Tuned Transistor Audio Amplifier. *Electronic Engng. 31*, 103 (1959).

Correction

In 'The Correspondent Replies' by R. H. Evans on page 558 of the September issue, the last line of the final equation should read:

$$\left.-\frac{V^d(0)\cos[\omega t+\phi_m=\phi_n-(d+1)\theta]}{(a^2+\omega^2)^{(d+1)/2}}\,e^{at}\right\}$$

BOOK REVIEWS

Digital Computer Components and Circuits

By R. K. Richards. 511 pp. 70 figs. Medium 8vo. D. Van Nostrand Co. Inc., New York, London. 1958. Price 64s.

DR. R. K. RICHARDS is already well known to engineers and others associated with digital computers for his earlier book, 'Arithmetic Operations in Digital Computers', which contains an excellent account of the logical design of the arithmetic units of various types of computers. Dr. Richard's new book deals with the circuits and components that are used in computer logic and storage. It has been written as a companion volume to the earlier book but it can be read as a self-contained account of the subject. Although the reader is assumed to have some knowledge of electronics, the book should prove of interest not only to engineers both in computing and allied fields, but also to the many users of computers, who, despite a very limited experience of electronics, would like to appreciate more of the engineering side of the machines that they use.

The techniques being used in computers are changing so rapidly that it is a formidable task to describe them all in one volume, and indeed it is impossible to ensure that all are included since new ones will be appearing even while the manuscript is with the publishers. However Dr. Richards has made a bold attempt to be as comprehensive as possible within these limits and, although some of the information is of only historical interest, most of the techniques that will be present in working computers for many years are described. Despite all the current news of new techniques it should be remembered that by far the majority of commercially available computers which are installed and working reliably use thermionic valves and that the next round of machines will be using transistor circuits. Both of these techniques are dealt with at length in this book.

For electronic engineers in other fields an introductory chapter outlines the general concept of a digital computer. This introduction also contains a short dissertation on reliability and marginal checking, sides of computer circuit design that cannot be too heavily emphasized. A chapter is devoted to diode switching circuits and a long chapter each to use of thermionic valves, transistors and magnetic cores in circuit logic. A brief account of the physics of transistors and cores is given. Many different examples of these various techniques are given, not all of which have found (or will find) their way into successful computers. However, where particular circuits have been used in practice the computers are mentioned and the speeds of operation achieved are quoted. Not unnaturally almost all these references are to American computers; from a knowledge of these machines the reader can judge the success of the appropriate circuit.

A wide range of storage devices is described, from the now almost extinct cathode-ray tube and mercury delay-line stores to the magnetic core store which is the store most used in currently planned computers. A chapter is devoted to storage on magnetic surfaces (drums and tape) and accounts of the various methods of recording are described.

Further chapters cover decimal counting circuits and analogue-to-digital and digital-to-analogue convertors. Under miscellaneous components the cryotron is described. As the author says it may seem ridiculous to consider operating a computer at temperatures very near to the absolute zero but advantages of simplicity, small size, high-speed, low power consumption and low cost, in fact all the attributes that a computer engineer looks for in his components, may well make it the computing component of the future.

The reader should find something about every type of computer component in this book, and even if the reference may be too short the excellent bibliography will indicate where further information may be obtained. In all, this is a useful book and one suspects that Dr. Richards will be called upon to produce further editions in order that it may keep abreast of developments in the field.

C. H. DEVONALD.

Electromagnetic Radiation from Cylindrical Structures

By J. R. Wait. 199 pp. 69 figs. Demy 8vo. Pergamon Press Ltd. 1959. Price 50s.

THE author of this book is one of the leading authorities on the theory of radio aerials and has written many papers and reports on the subject. This book is partly a collection of his publications, some of which are incorporated with only minor modifications. It is useful to have this material in one volume, especially as it also includes a review of papers from the U.S.S.R.

The book will be intelligible only to the most accomplished mathematicians. After eight pages of introductory material the author plunges into the mathematics, making free use of Bessel and Hankel functions. After that there is hardly a page without these or some other transcendental function. The statement on the dust-cover that the reader . . . "requires knowledge of complex functions and electromagnetism at the intermediate level" is misleading, for only readers with good final honours mathematics will understand this book.

A review of the basic concepts of electromagnetism is given in an appendix. This is too brief to be recommended to students new to the subject, but the reader experienced in electromagnetic theory will find it a useful summary and will note some novel features of the presentation—he may not agree with them all.

The main aim of the book is to show how to compute the radiation patterns of slot radiators and dipole or stub aerials in or near wedges, cylinders and similar structures, and there are many diagrams of radiation patterns. There are also chapters on scattering from a dielectric cylinder and on diffraction by a cylindrical surface.

There is a long bibliography, mostly of mathematical papers, but no index—an omission which greatly reduces the value of any book. The bibliography does not include any of the series of pioneering papers in vol. 93, part IIIA of the Journal of the Institution of Electrical Engineers. Some of these are still of value to the practical engineer, but were perhaps thought to be of insufficient mathematical interest.

K. G. BUDDEN.

Electronic Engineers Reference Book

Edited by L. E. C. Hughes. 1 588 pp. 9 584 figs. Crown 8vo. 2nd Edition. Heywood & Co. Ltd. 1959. Price 84s.

A LARGE part of the text of this new edition has been revised and a considerable amount of new material added, notably new sections on non-destructive testing, components, special components, radiation detection, digital computer applications, simulators and electronic telephone exchanges.

This reference book endeavours to put before engineers in industry and in development laboratories, some of the latest knowledge and techniques which might not be easily available to them. It provides suggestions and possibilities to be taken into consideration when problems are examined from various points of view, physical, chemical, production, safety, reliability and maintenance.

The Fourier Integral and Certain of its Applications

By N. Wiener. 199 pp. Demy 8vo. 2nd Edition. Dover Publications Inc., New York, Constable & Co., London. 1959. Price 12s.

THIS new paper covered edition is in substance an elaboration of a course of fifteen lectures on the Fourier Integral and its Application, given at the University of Cambridge during 1932. The author's development of certain theories concerning the Fourier Integral—notably those of Plancherel and Tauber—have made it possible to apply analytical techniques to areas in physics and engineering which are basically statistical in nature.

Logical Design of Digital Computers

By M. Phister Jr. 408 pp. 60 figs. Medium 8vo. John Wiley & Sons Inc., New York. Chapman & Hall Ltd, London. 1958. Price 84s.

DR. PHISTER has produced a book on the logical design of digital computers which tackles the problem in a far more algebraic way than most writers have done previously. One expects that such a book will contain many diagrams of adders, multipliers, control circuits and so on, where each diagram comprises 'black boxes' representing the logical elements, the shape of the unit defining the particular function that the element carries out. Turning the pages of this book, however, one finds that there is a marked absence of diagrams and in their place are equations and it is these Boolean equations that define the computer.

The design of a computer can be divided conveniently into three parts which are to a large extent independent. First, the computer has to be specified in general terms (size of internal storage required, speed of operation, types of input and output equipment) so that it can do the job for which it is intended. Secondly, the electronic circuit elements from which this system is to be built must be designed. Finally, the arrangement of the inter-connexions between these units must be worked out so that the resulting machine meets the system specification. It is this last stage that is the logical design of the computer in the sense of Dr. Phister's book, and the ultimate product of this design is the wiring schedule from which the computer is constructed. As Dr. Phister says in his introduction the system specification and electronic design work call for flair and inspiration, but much of the detailed work of logical design can be reduced to rules and hence this step can more and more become an activity that can be automatically handled by a suitably programmed computer. The algebraic approach of this book should be particularly suited to this form of mechanization.

The early chapters outline the basic parts of a computer and the electronic units that go to make up these parts. These circuit elements are defined in terms of Boolean functions and the remainder of the book is concerned with the building of the different parts of a computer considered as a problem in Boolean algebra. Only serial, synchronous computers are dealt with, but if the design problems of such computers are understood other types of computers can be readily mastered. In order that the Boolean operations involved can be appreciated by the reader (who may well be unfamiliar with this subject) an extensive account of Boolean algebra is given, including several methods of simplifying Boolean functions. Since each term in these Boolean functions corresponds to a logical element in the resulting computer, these simplifications tend to reduce the equipment involved. Brief descriptions are given of various storage devices, such as magnetic drums and tape, and input and output units such as paper tape and card readers and punches, and the ways in which these fit into the computer design are outlined.

To one more familiar with the diagrammatic approach this treatment is at first difficult to understand. Dr. Phister claims that in his experience the algebraic approach has many advantages to offer as computers become more and more complicated. One feels, however, that while this method may appeal to mathematicians (and many logical designers are mathematicians by training) there is still a place for the logical diagram to assist the maintenance engineer whose background is usually of a more practical nature.

Dr. Phister indicates that his book is intended to form the basis for a university course and it is well supplied with exercises. However, no solutions are given and one feels that a student's supervisor would be kept busy in producing the answers—one exercise, for instance, begins, 'Design a serial decimal general-purpose computer having the following order code: .....'

With so many books appearing on various aspects of computers it is refreshing to find a novel approach and Dr. Phister is to be congratulated on this account. The presentation is good and in such a difficult text there is a surprising absence of misprints. As is usual these days an extensive bibliography concludes each chapter.

C. H. DEVONALD.

Electron Physics and Technology

By J. Thomson and E. B. Callick. 527 pp. 70 figs. Demy 8vo. English Universities Press Ltd. 1959. Price 50s.

AS the title implies, this book attempts to give a comprehensive account of the wide range of electron physics from the basic theory up to the technology of modern devices. This is a formidable task in which the authors have not quite succeeded. The main defects lie in the first two sections of the book covering the basic theory and entitled: 'Free and bound electrons,' and 'Electronic devices employing space-charge variation.' These sections are too much condensed to form an adequate introduction to electron physics *per se* although they may form a sufficient basis for an understanding of the rest of the book. In addition there are a number of minor errors, such as symbols in diagrams differing from those in the text, and also some which are rather more serious. For example in the chapter on electronic conduction in a vacuum the equations for the motion of an electron in combined electric and magnetic fields (3·1) are valid if, for the charge on an electron, the substitution $e = -1{\cdot}6 \times 10^{-19}\ C$ is made, whereas for the following equations to be correct the magnitude of e $(+1{\cdot}6 \times 10^{-19}\ C)$ must be used. There is a similar confusion in the analysis leading to the equivalent circuit of the triode.

The following sections entitled 'Electron Inertia,' 'Microwave Devices' 'Special Purpose Tubes,' and 'Materials and Construction,' are much better and indeed the book is written essentially from the point of view of the technologist. A considerable amount of material on the technology of electron devices is presented in a very readable form although occasionally technical terms are used without explanation.

Electronics degree courses are so overcrowded that scarcely any mention of technology is possible. This book helps to bridge the gap between theory and practice and may be recommended to students of electronics as an introduction to the technological aspects. In its present form it is not very suitable as an introduction to electron physics, and in order to achieve this aim the initial sections should be expanded appreciably and rather more carefully written.

W. A. GAMBLING.

Jets and Rockets

By A. Barker, T.R.F. Nonweiler and R. Smelt. 245 pp. 121 figs. Demy 8vo. Chapman & Hall Ltd. 1959. Price 35s.

THE development of the rocket and jet unit is closely linked with the advance of high-speed aerodynamics and this fact might almost be described as the theme of this book.

The eighteen chapters include discussions on the momentum theory of jet and rocket propulsion, the rocket motor, performance calculations, jet propulsion, air resistance and aerodynamic design at high speeds, engine performance and the performance of rocket projectiles, ending with a chapter on future developments, appendices and a bibliography.

EE 15 265 *for further details*

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ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

(Voir page 567 pour la traduction en français: Deutsche Übersetzung Seite 572)

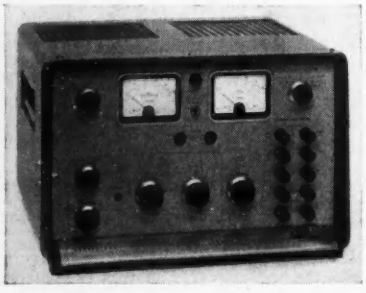
STABILIZED POWER SUPPLY UNIT

(Illustrated below)

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

The Advance stabilized power supply type L.101 is a special purpose instrument of considerable flexibility which provides a constant voltage source of 600V positive and two stabilized negative 150V d.c. supplies, one of which is a variable line having a high impedance source. Two stabilized 6·3V 4A a.c. supplies are also provided.

A stabilized variable 0 to 150V negative line of high source impedance is provided as a grid bias supply or for use in circuits drawing a small current



load of not more than 5mA. A 100 to 800V unstabilized line is also provided for general use.

The two positive lines have a maximum total load rating of 300mA. The positive 600V and negative 150V d.c. outputs may be used in series to provide a total 750V stabilized d.c. output with a maximum rating of 30mA.

Voltage variation on the positive 600V and negative 150V lines is better than 0·03 per cent of output for a 10 per cent change of input voltage, and the variation in output from the two 6·3V a.c. lines is less than 0·02V for the same condition.

The output impedance is less than 0·1Ω at d.c. and less than 0·5Ω at 50kc/s on all d.c. lines. The variable negative 0 to 150V d.c. line has a source impedance of 12kΩ. Ripple content is less than 3mV r.m.s. on all stabilized outputs at 150V and below. Above 150V the ripple content is less than 0·002 per cent r.m.s. and on the unstabilized 100 to 800V d.c. it is about 3V r.m.s. at 800V with 300mA load.

Adequate metering facilities are provided by two first grade meters, the voltmeter being calibrated from 0 to 250V and 0 to 1kV, and the ammeter from 0 to 50mA and 0 to 500mA.

Other facilities include control of the h.t. stabilized d.c. line enabling the output to be set to any desired level from 0 to 600V together with a source resistance control over the range 0 to 40Ω. Hum can be superimposed on the stabilized d.c. h.t. line and may be varied between 0 and 6V r.m.s. to give a good quality sine wave at the mains input frequency.

All outputs are floating with respect to the chassis, the positive and negative lines being connected through the neutral terminal.

EE 15 751 *for further details*

PULSE OSCILLOSCOPE

(Illustrated below)

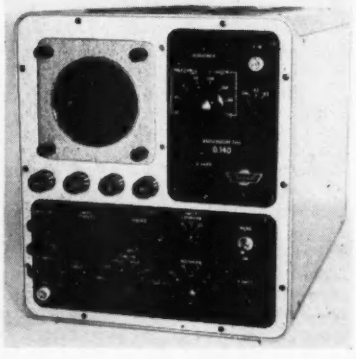
Furzehill Laboratories Ltd, 57 Clarendon Road, Watford, Hertfordshire.

The Furzehill 0·140 oscilloscope, now in full production provides facilities for pulse and r.f. examination at a competitive price. It embodies a time-base which can be used in either triggered or free-running condition over a range of 0·1μsec/cm to 0·5sec/cm. A useful feature is the fine control of the triggering which enables the horizontal sweep to be started at any desired point on the waveform under examination. On recurrent setting positive and immediate synchronism is provided by a separate sync amplifier which may be fed either from the internal amplifier or from an external source.

The deflexion amplifier is direct-coupled and is provided with 8 calibrated sensitivities, namely 50, 15, 5, 1·5, 0·5 and 0·15V/cm level to 10Mc/s plus two further sensitivities of 50mV/cm to 3·3Mc/s and 15mV/cm to 1Mc/s. Because the instrument is intended for pulse examination, the amplifiers are critically damped to obviate ringing.

The calibration accuracy on both time and voltage is better than 5 per cent but an internal calibrating wave of 1 per cent accuracy enables a check to be made at any time.

A four-inch p.d.a. flat-ended tube is used with astigmatism control, while the



graticule is provided with variable illumination which facilitates rapid and accurate measurement.

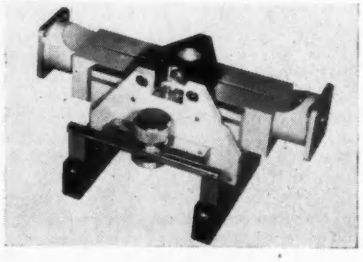
EE 15 752 *for further details*

WAVEGUIDE SLOTTED SECTIONS

(Illustrated below)

Distributed by: Leland Instruments Ltd, Abbey House, Victoria Street, London, S.W.1.

These instruments, manufactured by the Polytechnic Research Development Co. of New York, provide accurate standing wave and impedance measurements in the microwave region from 2·6 to 40kMc/s. They may be used both in design and routine tests for obtaining v.s.w.r. and



phase data on waveguide components or employed in conjunction with tuning devices to eliminate transmission line mismatches. In addition they may be used as permanent parts of radar and communication systems for checking antenna reflection characteristics. The frequency range is covered in eight standard waveguide sizes.

The slotted section consists of a length of waveguide, precisely machined from a solid block of metal, with a narrow longitudinal slot in the centre of the top wall. A carriage is provided to move the pick-up probe along the length of the slot. This carriage is supported on three ball bearings which roll in precision-ground and hardened grooved runways attached to the body of the unit. Adjustment of the motion of the carriage with respect to the body is provided so that the probe tip can be made to move accurately parallel to the inside surface of the waveguide.

Probe carriages are designed to provide smooth and accurate carriage motion, without backlash or play. The absence of sliding contacts reduces wear to a minimum and instrument accuracy is maintained indefinitely.

For facilitating precise phase measurements, each slotted section is equipped with a vernier centimetre scale which indicates the distance between the probe and the outer end. The probe travel is approximately one guide wavelength at the lowest frequency in each range, except

in the two lower frequency lines where it is three-quarters wavelength. Waveguide inside dimensions are maintained accurately to provide a standard of impedance. Slot ends are tapered to reduce the residual v.s.w.r. below 1·01, except in the two lower frequency lines where the discontinuity is negligible.

EE 15 753 *for further details*

CONDUCTIVITY BRIDGE

(Illustrated below)

A. M. Lock & Co. Ltd, Prudential Buildings, 79 Union Street, Oldham, Lancashire

The Lock portable conductivity bridge, type BC1, uses the latest transistor circuits and manufacturing techniques to ensure long trouble-free service under laboratory or field conditions. It is housed in a wooden carrying case measuring approximately 12in × 7½in × 5½in overall, and is supplied complete with a dip type conductivity cell.

Ease of operation and reading is ensured by carefully positioned controls, clearly marked on the sloping front panel. A quick release wooden lid gives protection for transit purposes; in use it is completely removed.

The a.c. measuring bridge is energized at a low potential by a 1·5kc/s transistor oscillator. This high frequency is used to overcome inaccuracies which would otherwise occur at high solution conductivities.

In use, bridge balance is shown by maximum deflexion of the indicator meter. The conductivity of the solution is then read from the large calibrated dial. By using this null-point method, variations in battery voltage or transistor characteristics do not affect the accuracy of measurement.

The instrument covers a measuring range, 0·5 micromhos to 1×10^6 micromhos in six ranges.

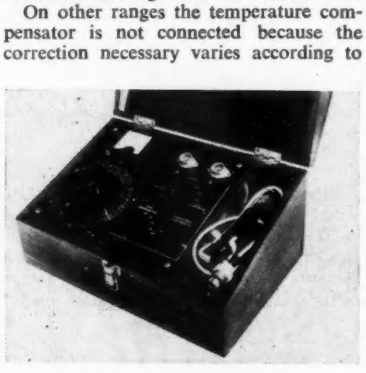
The bridge is suitable for use with most types of conductivity cell. If the cell has a constant other than unity, the actual solution conductivity is obtained by multiplying the bridge reading by the cell constant.

Manual temperature compensation over the range 5 to 35°C is provided on Ranges 2 and 3 at the rate of 2 per cent/°C. This correction factor covers certain condensates and unprocessed waters, and most aqueous solutions with conductivity values in the range 5 to 1 000 micromhos.

On other ranges the temperature compensator is not connected because the correction necessary varies according to the composition and concentration of the electrolyte.

A built-in variable capacitor is provided to balance out cell and cable capacitance which would otherwise give a flat balance point.

EE 15 754 *for further details*



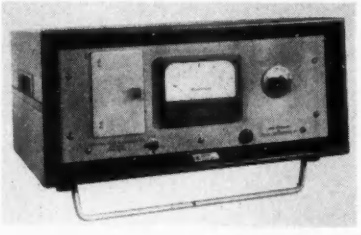
VIBRATING REED ELECTROMETER

(Illustrated below)

Ekco Electronics Ltd, Southend-on-Sea, Essex

The vibrating reed electrometer type N616 has been designed to measure very small direct currents and voltages with high zero stability. The d.c. input is converted to a.c. by means of a vibrating reed capacitor and amplified by a stable a.c. amplifier.

Seven ranges are provided—3, 10, 30, 100 and 300mV and 1 and 3V. The output is rectified and measured on a 5in panel meter calibrated to indicate the d.c. voltage at the input.



For voltage measurements, accuracy is about ±5 per cent while current measurements may be made to the same accuracy provided that the total value of the input resistance is known and the calibration control is adjusted as necessary.

EE 15 755 *for further details*

NON-LINEAR FUNCTION GENERATOR

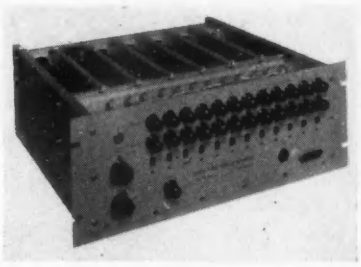
(Illustrated above right)

The Solartron Electronic Group Ltd, 45 Thames Street, Kingston, Surrey.

Recently announced by Solartron is the diode function generator type TR 829. In standard 19in rack-unit form, the TR 829 will generate precise functions of a variable to a high degree of accuracy and stability. It is complementary to the existing range of Solartron non-linear analogue computing units.

The function required is generated in 12 segments, simply set-up by adjusting break points for each segment against a digital voltmeter monitor. These adjustments are made on high-resolution helical potentiometers, over the voltage range zero to plus or minus 100V. Two TR 829 units may be used together if desired, for more complex functions.

The diode function generator incorporates a total of 14 high-gain d.c. amplifiers and does not require additional operational amplifiers to provide full output. Drift and gain errors for each segment are held inside 100mV and 0·2 per cent respectively, and, since these errors are non-cumulative over the whole function generated, the long-term stability overall is always better than 0·5 per cent average.



EE 15 756 *for further details*

DIFFERENTIAL TRANSFORMER TRANSDUCER

(Illustrated below)

James Scott & Co. (Electrical Engineers) Ltd, 68 Brockville Street, Carntyne Industrial Estate, Glasgow, E.2.

In the basic LINTRAN instrument the input is the movement of a shaft and the electrical output is accurately proportional to this movement. However, it is not limited to this function only, since by the addition of calibrated bellows it becomes a pressure measuring gauge and so on. In fact, any quantity in which a change can be translated into movement can be accurately measured by this device.

The LINTRAN uses the well-known principle of a 'differential transformer'. This has two windings accurately spaced relative to a central winding so that the signals from the windings are equal. If an iron armature is now placed inside the windings, movement of this armature results in changes of the internal magnetic fields and the outputs are no longer equal. By careful design the difference in the output can be made accurately proportional to the movement of the armature from its central position. The difference in output is normally shown on a meter which can be scaled directly in terms of movement of the armature. In this design the size of the armature which is included can be varied, and depending on this size full scale movement on the meter can be obtained for as small a movement of the input shaft as one thousandth of an inch or as large as one inch.

Previous transducers using the differential transformer arrangement have tended to be large and cumbersome when designed for use on the normal mains supply. Alternatively, they have required the addition of expensive electronic cir-

cuits to obtain the accurate output required. The LINTRAN, however, has been designed for operation on the normal supplies, but the advantages of a small size, plus accurate output have been retained.

The basic unit is 7¼in long by 1¾in diameter and weighs 2lb (907grms).

EE 15 757 *for further details*

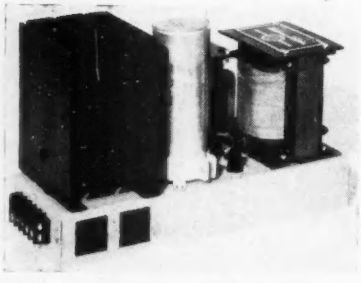
LOW VOLTAGE POWER SUPPLY

(Illustrated below)

Allied Electronics Ltd, 28 Upper Richmond Road, Putney, S.W.15.

The LS353-H supply unit is intended for use in situations requiring a compact, stabilized d.c. source such as heater supplies in d.c. amplifiers, exciter lamps in photo-electric measuring instruments and other applications where batteries are normally used.

The basic unit is a germanium junction rectifier circuit with a transistor voltage stabilizer and a reference potential device.



The system described above is a development of the 'Altron' constant potential chargers supplied for use with 'DEAC' mercury-cadmium, hermetically sealed accumulators. 'DEAC' chargers are available for a range of voltages from 1·5V to 24V and currents up to 100A or more.

The circuit provides a high degree of stabilization against changes in input voltage, and a low ripple content: a pre-set control permits variation of the output voltage over a small range.

Supply units are available either in chassis form or in cases.

EE 15 758 *for further details*

CAPACITANCE SENSING TACHOMETER

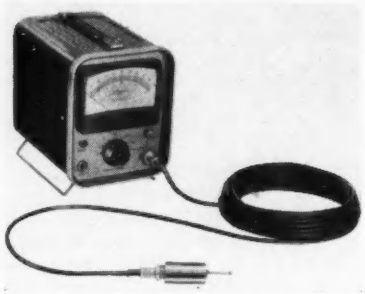
(Illustrated above right)

Grunther Instruments Ltd, 14 Oriental Street, London, E.14.

This capacitance sensing tachometer was developed for a project which required the measurement of gas turbine speeds of up to 120 000rev/min with local temperatures up to 700°C.

This equipment makes use of a probe mounted near to, but not in contact with, any irregularity on a rotating part moving at the speed to be measured or at some multiple or sub-multiple of it. The irregularity may be a keyway, spline, cam, gear tooth, large hexagon nut, or a hole or pip not smaller than 1/16in in diameter and depth.

Each time the irregularity (prominance or depression) passes the probe, a capacitance change is produced. This develops a voltage pulse which is fed via a small diameter flexible cable to the counting instrument, which may be up to several hundred yards distant from the probe.



The tachometer itself is an electronic counting instrument using established techniques. The indicator is a moving-coil meter calibrated directly in revolutions per minute. There are six reading ranges which, with the use of correction factors in certain cases, permit measurements from below 50rev/min to 200 000rev/min with an accuracy better than 2 per cent of full-scale deflexion throughout.

The probe, although sensitive to capacitance changes, is unaffected by extremes of temperatures, vibration or the presence of oils etc.

EE 15 759 *for further details*

STABILIZED DUAL LOW VOLTAGE SUPPLY

(Illustrated below)

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex.

The P.P.3 comprises two transistorized 0 to 30V 1A stabilized d.c. power supplies in one case operating off a common mains transformer. The two sections are floating and can be operated separately, connected in series to give a maximum output of 60V at 1A or to provide positive and negative voltage supplies simultaneously (max. 30V each).

Each section covers the range from 0 to 30V in three overlapping 10V ranges with the variable control directly calibrated in volts. In addition to this a voltmeter and ammeter are provided which can be independently switched to either section, the ammeter having two ranges.

Four terminal output networks are provided to enable the resistance of the connecting leads to the load to be virtually eliminated.

Overload protection is effected by an electronic circuit which gives complete protection against both progressive and sudden (short-circuit) overloads. This circuit being reset from the front panel by operation of the on-off switch. Protection against internal failure or excessive mains surges is handled by a panel mounted fuse in the mains circuit.

EE 15 760 *for further details*

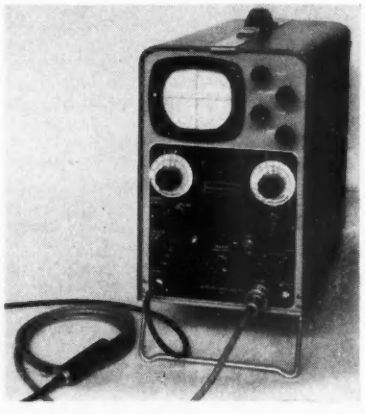
PULSE MONITORING OSCILLOSCOPE

(Illustrated below)

Mullard Equipment Ltd, Mullard House, Torrington Place, London W.C.1

Mullard Equipment Limited have introduced a new and inexpensive type of pulse monitoring oscilloscope with the fast rise-time of 2mμsec, equivalent to a bandwidth of d.c. to 220Mc/s.

The instrument, type L.362, has been



designed for the display or measurement of pulses of between 3mμsec and 3μsec duration, and will therefore have particular value in nucleonic and computer research work, and for the examination of radar pulses, especially in short-range, high-resolution equipment.

Apart from its very wide bandwidth, the L.362 has several other notable features. The sensitivity is 150mV/cm, which, combined with the d.c. coupled amplifiers, makes the instrument particularly suitable for work on transistor circuits. The input probe is compact, easily handled, and imposes a load of only 2pF on the circuit under investigation. There are facilities for displaying identically shaped pulses of random separation, as occur, for example, with nuclear detectors; and short pulses of low p.r.f. can be displayed with high brightness. Finally, due to the extensive use of transistors, the instrument is portable and compact.

The L.362 has been developed from a design of the Atomic Energy Research Establishment, Harwell, and makes use of the sampling principle: the complete c.r.t. trace is built-up, as a low-frequency replica of the input, of a series of dots, each of which corresponds to a sample taken from successive repetitions of the input. A charge storage circuit maintains the position of a dot until the succeeding

sample is taken. Hence, under most conditions, the c.r.t. beam is 'on' for about 80 per cent of the cycle time, and a display of high brilliance is obtained without post deflexion acceleration.

The functional centre of the instrument is the comparator and the X and Y charge-storage circuits. The output of the X charge-storage circuit is compared with a time-base waveform from the fast sweep generators, and when these are equal the comparator produces a pulse which triggers the sampling circuits. Simultaneously, a pulse is passed to the X charge-storage circuit, thus reducing the stored-charge. The sampling trigger pulse therefore occurs relatively earlier, and the cathode-ray tube spot moves to the left on succeeding repetitions of the input waveform. When the stored charge falls to a predetermined level the circuit is reset and the flyback occurs.

The input to be displayed is applied to the sampling circuit, which is contained in a small, separate probe. The input voltage charges the input capacitance of the instrument, and when the sampling trigger pulse is received this charge is transferred via the charge amplifier to the Y charge-store. The stored charge is thus proportional to the input voltage at the instant of sampling.

A second pulse from the X circuit is passed to the Y charge-store, and the voltage corresponding to the stored charge is then applied to the Y plates of the c.r.t. via the Y deflexion amplifier. The X charge-storage circuit also produces pulses which black out the tube while the spot is moving.

A second input of triggering pulses, which must precede the signal input by between 0·05 and 2μsec, is applied to the trigger delay, and thence to the fast sweep generator, which produces the time-base waveform applied to the compartor.

EE 15 761 *for further details*

IMAGE CONVERTOR POWER UNIT

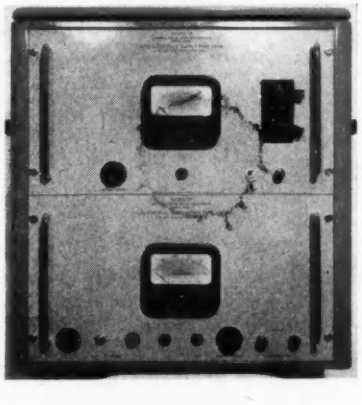
(Illustrated below)

Sionic Ltd, Cromwell House, 93 Wood End Green Road, Hayes, Middlesex.

The stabilized power supply unit type 359A has been designed specifically for the operation of Mullard image convertor tubes.

The current stabilized focus coil unit supplies 200 to 500mA for a nominal load of 700Ω. A change of load by ±100Ω gives a current change of 1 per cent. The ripple is less than 50μA and the mains input and temperature stability better than 1 per cent.

The e.h.t. supply unit provides 5 to 14·5kV at 1μA with a grid supply tapping to give 1μA. Without the grid supply the current available is 100μA. The ripple is less than 1V peak-to-peak and the overall stabilization better than 2 per cent.



EE 15 762 *for further details*

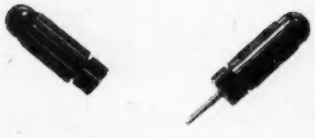
MINIATURE PLUGS AND SOCKETS

(Illustrated below)

Harwin Engineers Ltd, Rodney Road, Portsmouth, Hampshire.

An extremely small plug and socket in Nylon, the Harwin W.3000/3001 can be mounted at only 3/16in centres. It has gold plated contacts which will carry up to 7·5A at 750V, contact resistance averages 2mΩ, insulation is better than 10^6Ω. Working conditions up to 100°C can be tolerated and vibration and impact resistances are stated to be excellent.

EE 15 763 *for further details*



IN-LINE DIGITAL DIALS

(Illustrated above right)

Amphenol (Great Britain) Ltd, Ormond House, 26/27 Boswell Street, London, W.C.1.

It is known that forced fast reading and setting of dials is a cause of errors in reading perception and it has been determined that for precise numerical values an inline digital presentation provides the greatest accuracy in conditions where fast reading and setting are required.

These facts have led to the development of the Borg 1300 series Microdials. To obtain the maximum advantages from inline digital presentation, numbers are made in direct contrast to their background, e.g. white on black or black on white. A large, one-piece curved and sealed window provides wide-angle viewing. For maximum sensitivity and accuracy, the control knob is mounted directly on the shaft to be controlled. Backlash, which could result from gearing, is thus eliminated.

Types are available with finger tip brakes to retain settings under conditions of shock and vibration. Available types are:

Model 1307 3 digit dial counting from 0 to 999 in ten turns of the control knob and fitted finger tip brake.

Model 1308—as above, without finger tip brake.

Model 1304—4 digit dial, counting from 0 to 9999 in 100 turns.

Model 1305—5 digit dial, counting from 0 to 99999 in 1 000 turns.

EE 15 764 *for further details*

V.H.F. SIGNAL GENERATOR

(Illustrated below)

Airmec Ltd, High Wycombe, Buckinghamshire.

A recently announced addition to the range of electronic instruments manufactured by Airmec Limited is the v.h.f. signal generator type 204.

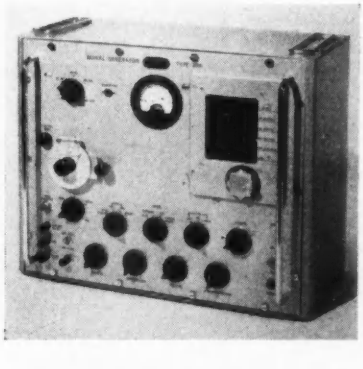
This instrument has a wide frequency coverage from 1Mc/s to 320Mc/s in five ranges. The operating frequency is shown on an illuminated film scale with a length of 4ft on each range, and a crystal check oscillator is incorporated to ensure absolute accuracy of calibration.

A notable feature is the stabilization of the output level at any value between 2μV and 220mV, which avoids the tedious checking and resetting of the output when a number of different frequencies are in use.

An internal 1kc/s oscillator is provided for amplitude or frequency modulation. Depth of modulation up to 50 per cent, or deviation up to 80kc/s, is monitored by a built-in meter to an accuracy of ±5 per cent. External modulation at any frequency from 30c/s to 15kc/s may also be applied either separately or simultaneously with the internal modulation. External pulse modulation with pulse repetition frequencies from 30c/s to 50kc/s may also be applied.

A constant impedance 52Ω step attenuator is fitted, and a matching cable is supplied to transform the source impedance to 75Ω when required.

EE 15 765 *for further details*



Meetings this Month

THE BRITISH COMPUTER SOCIETY LIMITED

Date: 25 November. Time: 6.15 p.m.
Held at: Northampton College of Advanced Technology, St. John Street, London E.C.1.
Lecture: The Metrovick 1010 Data Processing System.
By: J. C. Gladman.

Birmingham Branch

Date: 9 December. Time: 6.30 p.m.
Held at: Large Theatre, Electrical Engineering Department, The University, Edgbaston.
Lecture: Bank Automation.

Hull Section

Date: 2 December. Time: 7.30 p.m.
Held at: Hull Chamber of Commerce, Samman House, Bowlally Lane, Hull.
Lecture: Bankers' Approach to Electronc Applications.
By: R. Hindle.

Liverpool Branch

Date: 24 November. Time: 6.30 p.m.
Held at: Mathematical Institute, University of Liverpool.
Lecture: Choosing and Installing a Computer—A Case Study.
By: A. J. Platt.

Manchester Branch

Date: 1 December. Time: 7 p.m.
Held at: Manchester College of Science and Technology, Sackville Street, Manchester.
Lecture: A Large Data Processing System.
By: W. E. Scott.

Newcastle Branch

Date: 1 December. Time: 7 p.m.
Held at: University Computing Laboratory, 1 Kensington Terrace, Newcastle.
Lecture: Linear Programming and its Applications.
By: A. Muir.

THE BRITISH INSTITUTION OF RADIO ENGINEERS

All London meetings will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London W.C.1.

Computer Group Meeting

Date: 10 December. Time: 6.30 p.m.
Lecture: The Simulation of Nuclear Reactors and Power Plants.
By: W. J. G. Cox and J. Dowsing.

North Western Section

Date: 10 December. Time: 6.30 p.m.
Held at: Reynolds Hall, College of Technology, Sackville Street, Manchester.
Lecture: Learning Machines.
By: P. Huggins.

South Midlands Section

Date: 27 November. Time: 7 p.m.
Held at: North Gloucestershire Technical College, Cheltenham.
Lecture: A Vidicon Television Camera Channel
By: B. J. Pover.

THE INSTITUTE OF PHYSICS

Date: 11 December. Time: 6 p.m.
Held at: The Institute of Physics, 47 Belgrave Square, London S.W.1.
Lecture: The Ultrasonic Camera—An Alternative Approach to Ultrasonic Testing.
By: J. F. Sayers.
Date: 11 December. Time: 6.15 p.m.
Held at: University College, Cardiff.
Annual General Meeting followed by:
Lecture: Nuclear Magnetic Resonance in Liquids.
By: Dr. J. A. Pople.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings will be held at Savoy Place, commencing at 5.30 p.m.

Electronics and Communications Section

Date: 25 November.
Lecture: Radio Aspects of the International Geophysical Year.
By: R. L. Smith-Rose.
Date: 7 December.
Lecture: Frequency Patterns for Multiple-Radio-Channel Routes.
By: B. B. Jacobsen.

Measurement and Electronics Sections

Date: 1 December.
Lecture: Frequency Variations of Quartz Oscillators and the Earth's Rotation in Terms of the N.P.L. Caesium Standard.
By: L. Essen, J. V. L. Parry and J. McA. Steele.

Ordinary Meeting

Date: 3 December.
Lecture: The Transmission of News Film over the Transatlantic Cable.
By: C. B. B. Wood and I. J. Shelley.

Cambridge Electronics and Communications Group

Date: 8 December. Time: 8 p.m.
Held at: Cavendish Laboratory, Free School Lane. Cambridge.
Lecture: The Reliability of Components.
By: G. W. A. Dummer.

North-Eastern Measurement and Electronics Group

Date: 7 December. Time: 6.15 p.m.
Held at: Rutherford College of Technology, Newcastle-on-Tyne.
Lecture: Dielectric Materials—Trends and Prospects.
By: C. G. Garton.

North Lancashire Sub-Centre

Date: 9 December. Time: 7.15 p.m.
Held at: North-Western Electricity Board Lecture Theatre, Jubilee Street, Blackburn.
Lecture: Subscriber Trunk Dialling.
By: D. A. Barron.

North Midland Centre

Date: 1 December. Time: 6.30 p.m.
Held at: Bradford Institute of Technology.
Lecture: A System for the Automatic Recognition of Patterns.
By: R. L. Grimsdale, E. W. Sumner, C. J. Tunis and T. Kilburn.

North Scotland Sub-Centre

Date: 10 December. Time: 7 p.m.
Held at: Electrical Engineering Department, Queen's College, Dundee.
Lecture: Automatic Digital Recording of Experimental Values.
By: W. H. P. Leslie.
Date: 11 December. Time: 7.30 p.m.
Held at: Robert Gordon's Technical College, Aberdeen.
Repeat of above lecture.

Rugby Sub-Centre

Date: 2 December. Time: 6.30 p.m.
Held at: Rugby College of Technology of Arts.
Lecture: A System for the Automatic Recognition of Patterns.
By. R. L Grimsdale.

South Midland Centre

Date: 4 December. Time: 6 p.m.
Held at: Midland Institute, Birmingham.
Lecture: The Jodrell Bank Radio Telescope.
By: H. C. Husband.
Date: 7 December. Time: 6 p.m.
Held at: College of Technology, Birmingham.
Lecture: Some Industrial Applications of Electro Heat.
By: E. May.

Tees-Side Sub-Centre

Date: 2 December. Time: 6.30 p.m.
Held at: Cleveland Scientific and Technical Institution, Middlesbrough.
Lecture: Subscriber Trunk Dialling.
By: D. A. Barron.

THE INSTITUTION OF MECHANICAL ENGINEERS

Date: 25 November. Time: 6 p.m.
Held at: The Institution, 1 Birdcage Walk, Westminster, London S.W.1.
Thomas Hawksley Lecture: The Effect of Nuclear Radiation on Engineering Materials.
By: Professor A. H. Cottrell.

THE JUNIOR INSTITUTION OF ENGINEERS

Date: 11 December. Time: 7.30 p.m.
Held at: Pepys House, 14 Rochester Row, Westminster, London S.W.1.
Inaugural Meeting:
Induction of Professor J. M. Kay as President 1959-60 and presentation of Awards won during the1958-59 Session followed by an address: The Engineer's Role in Nuclear Power.

THE RADAR AND ELECTRONICS ASSOCIATION

Date: 24 November. Time: 7.30 p.m.
Held at: The Royal Society of Arts, John Adam Street, Adelphi, London W.C.2.
Lecture: Waveguides for Long Distance Communications.
By: Professor H. M. Barlow.

THE TELEVISION SOCIETY

Date: 3 December. Time: 7 p.m.
Held at: Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London W.C.2.
Lecture: Television in Germany.
By: Dr. R. Möller.

WOMEN'S ENGINEERING SOCIETY

Date: 9 December. Time: 7 p.m.
Held at: 'Hope House', 45 Great Peter Street, Westminster, London S.W.1.
Lecture: Radar and Telecommunications Research and Development.
By: Dr. E. Laverick.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Data Processing Section

Date: 7 December. Time: 7 p.m.
Held at: Manson House, 26 Portland Place, London W.1.
Lecture: Discontinuous Skill Teaching Machines.
By: G. Pask.

Manchester Section

Date: 8 December. Time: 6.45 p.m.
Held at: 'Manchester Room', Central Library, St. Peter's Square, Manchester 1.
Lecture: Instrumentation of the Dounreay Reactor.
By: K. R. Sandiford.

Midland Section

Date: 11 December. Time: 7 p.m.
Held at: Lecture Theatre, Byng Kendrick Suite, The Gosta Green College of Technology, Aston Street, Birmingham.
Lecture: Radioactive Isotopes in Industry.
By: W. G. Busbridge.

South Wales Section

Date: 25 November. Time: 6.45 p.m.
Held at: Newport & Monmouthshire College of Technology, Newport.
Lecture: Transistors.
By: S. S. Goldberg.

Tees-Side Section

Date: 10 December. Time: 7.30 p.m.
Held at: Cleveland Scientific & Technical Institute, Corporation Road, Middlesbrough.
Lecture: Practical Applications of Strain Gauge Weighing.
By: E. I. Lowe.

PUBLICATIONS RECEIVED

INSULATION FOR SMALL TRANSFORMERS—A GUIDE TO DESIGN AND TESTING by J. H. Mason and C. G. Garton is a handbook providing guidance and data for designers of all forms of electrical insulation, and will be useful for assessing the applications of new materials, and the insulation requirements for onerous or unusual service conditions. Although largely based on experience at the Electrical Research Association, this book presents data from many other sources and 136 references are given. The Electrical Research Association Laboratory, Cleeve Road, Leatherhead, Surrey. Price 37s. 6d. plus postage.

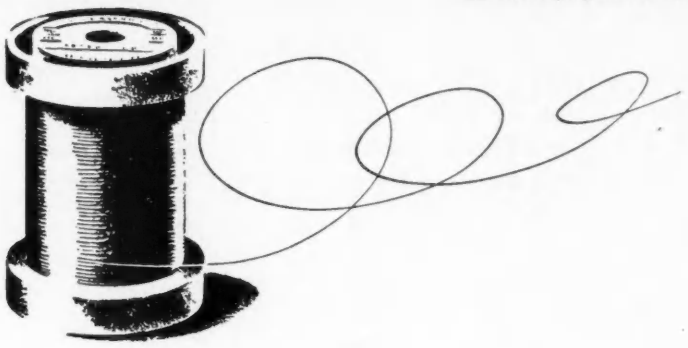
TRAINING SERVICES IN INDUSTRY is a booklet just published by the Industrial Training Council describing what some employers' organizations and joint bodies are doing in the way of providing training services for the benefit of the firms in their industries. The Council was set up a year ago to keep under review the recruitment and training of workpeople and to encourage, assist and inform industries about these matters. This story of the development of training schemes and advisory services describes the main functions of these services under the headings: Provision of information; Practical training and training aids; Supervision of training and further education; Recruitment; Selection and induction; Indenture and Registration; Tests and certificates and research into training methods. Industrial Training Council, 36 Smith Square, London S.W.1. Price 1s. 6d.

SIEMENS HALL GENERATORS FOR ALL PROBLEMS OF MODERN ELECTRONICS and **PHOTOELECTRIC COMPONENTS OF HIGH LIGHT-SENSITIVITY** are two catalogues on new Siemens & Halske devices. Copies can be obtained from their authorized agents and distributors R. H. Cole (Overseas) Ltd, 2 Caxton Street, Westminster, London S.W.1.

THE CALCULATION OF THE MEDIAN SKY WAVE FIELD STRENGTH IN TROPICAL REGIONS is a special report by the Department of Scientific and Industrial Research, published by Her Majesty's Stationery Office, price 2s. 6d. The analysis given in this report is presented in a form in which it is reasonably simple to identify the type of ionospheric reflection which is likely to be effective in particular circumstances.

(*Pages 703 to 712 French and German Sections*)

EE 15 119 *for further details*



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The following pages *contain French and German translations of our "Electronic Equipment" pages and summaries of the main articles. It will be noted that each item in the "Electronic Equipment" Section concludes with a number. These numbers are for the use of readers who require further information about particular items and should be quoted on the Reader Information Service Card at the end of the journal.*

Advertisement pages, facing matter, can be included in this Language Section for British and Overseas advertisers. Details on application to "The Advertisement Manager".

Les pages qui *suivent contiennent des traductions en français et en allemand de nos pages d'ÉQUIPEMENT ELECTRONIQUE, ainsi que des resumés des principaux articles.*

On remarquera que chaque article dans la section ÉQUIPEMENT ELECTRONIQUE se termine par un numéro. Ces numéros sont à l'usage des lecteurs qui pourraient avoir besoin de renseignements complémentaires au sujet de certains de ces articles et ils doivent donc être rappelés sur la carte du "Service de Renseignements aux Lecteurs" à la fin de la revue.

Des pages d'annonces et de publicité en regard d'elles peuvent être réservées dans cette Section Etrangère aux annonceurs britanniques et d'outre-mer. Pour plus de détails, s'adresser au Chef de la Publicité.

Auf den folgenden *Seiten bringen wir französische und deutsche Übersetzungen der Seiten „Elektronische Geräte" und der Zusammenfassungen der Hauptbeiträge.*

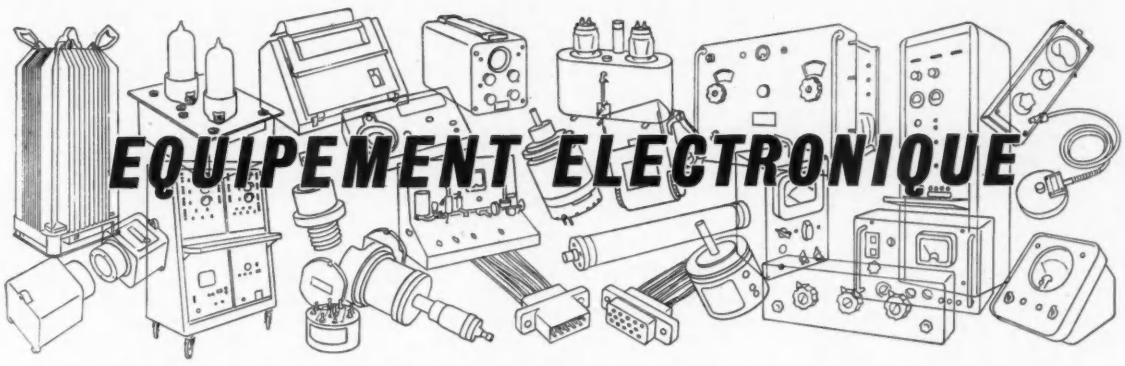
Am Fusse jeder Beschreibung in der Rubrik „Elektronische Geräte" steht eine Nummer. Leser, die an weiteren Auskünften über bestimmte Geräte interessiert sind, werden gebeten, diese Nummer auf der Leserdienstkarte am Ende des Heftes anzugeben.

Anzeigen britischer und ausländischer Firmen können auf Seiten gegenüber fremdsprachigem Text erscheinen. Einzelheiten bitten wir vom „Leiter der Anzeigenabteilung" anzufordern.

Electronic Engineering

28 ESSEX ST., STRAND, LONDON, W.C.2, ENGLAND

Telephone: CENtral 6565 *Telegrams: 'Lectroning, Estrand, London'*



EQUIPEMENT ELECTRONIQUE

Une description basée sur des renseignements fournis par les fabricants de nouveaux organes, accessoires et instruments d'essai

Traduction des pages 698 à 701

BLOC D'ALIMENTATION STABILISÉE

(Illustration à la page 698)

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

Le bloc d'alimentation stabilisée Advance Type L.101 est un appareil à usage spécial d'une souplesse considérable, qui fournit une source constante de tension positive de 600 volts c.c. et deux alimentations négatives stabilisées de 150 volts, dont l'une est une ligne variable ayant une haute source d'impédance. Deux alimentations de 6,3 volts, 4A, c.a. peuvent également être fournies.

Une ligne négative stabilisée variable de 0 à 150 volts, d'une haute impédance de source est prévue comme alimentation de polarisation de grille ou pour l'utilisation dans des circuits portant une faible charge de courant, ne dépassant pas 5 mA. Une ligne non-stabilisée de 100 à 800 volts est également prévue pour l'usage général.

Les deux lignes positives ont une charge nominale maximum de 300 mA au total. La sortie positive de 600 volts c.c., ainsi que la sortie négative de 150 volts c.c., peuvent être employées en série pour fournir une sortie totale de courant continu stabilisé de 750 volts, avec un régime maximum de 30 mA.

La variation de tension sur la ligne positive de 600 volts et sur la ligne négative de 150 volts est supérieure à 0,03% de la sortie, pour un changement de tension d'entrée de 10% et la variation de sortie des deux lignes de 6.3 volts c.a. est inférieure à 0,02 volts dans les mêmes conditions.

L'impédance de sortie est inférieure à 0,1 ohm sur courant continu et inférieure à 0,5 ohm à 50 kHz sur toutes les lignes de courant continu. La ligne négative variable de 0 à 150 volts c.c. a une impédance de source de 12 kiloohms. La tension d'ondulation est inférieure à 3 mV efficaces sur toutes les sorties stabilisées, à 150 volts et au-dessous. Au dessus de 150 volts, l'ondulation est inférieure à 0,002% de valeur efficace, et sur le courant continu non stabilisé de 100 à 600 volts elle est d'environ 3 volts efficaces à 800 volts, avec une charge de 300 mA.

Deux excellents enregistreurs indiquent les mesures effectuées, le voltmètre étant étalonné de 0 à 250 volts et de 0 à 1 kV, et l'ampèremètre de 0 à 50 mA et de 0 à 500 mA.

Les avantages multiples qu'offre l'appareil comprennent la possibilité de contrôler la ligne de courant continu stabilisé haute tension, de façon à régler la sortie à n'importe quel niveau entre 0 et 600 volts, ainsi qu'une commande de la résistance de source dans la gamme de 0 à 40 ohms. On peut également superposer la tension de ronflement à la ligne de courant stabilisé h.t. et la faire varier entre 0 et 6 volts efficaces afin d'obtenir une onde sinusoïdale satisfaisante à la fréquence principale d'entrée.

Toutes les sorties sont flottantes par rapport au châssis, les lignes négatives et positives étant reliées à travers la borne neutre.

EE 15 751 *pour plus amples renseignements*

OSCILLOSCOPE D'IMPULSIONS

(Illustration à la page 698)

Furzehill Laboratories Ltd, 57 Clarendon Road, Watford, Hertfordshire.

L'Oscilloscope Furzehill 0,140, actuellement en pleine production, permet l'examen d'impulsions et de hautes fréquences à un prix compétitif. Il comprend une base de temps qui peut être employée soit par déclenchement soit en marche libre dans une gamme de 0,1 μsec/cm à 0,5 sec/cm. Une caractéristique d'importance de l'appareil est constituée par le réglage précis du déclenchement qui permet de commencer le balayage horizontal à i'importe quel point voulu de la forme d'onde sous examen. Pour le réglage périodique, le synchronisme positif et immédiat est effectué par un amplificateur à part pouvant être alimenté soit par l'amplificateur intérieur soit par une source extérieure.

L'amplificateur de déviation est à couplage direct et il comporte 8 sensibilités étalonnées, soit 50, 15, 5, 1,5, 0,5 et 0,15V/cm de niveau à 10MHz, plus deux autres sensibilités de 50 mV/cm à 3,3MHz et 15mV/cm à 1MHz. Etant donné que l'instrument est destiné à l'examen d'impulsions, les amplificateurs sont à amortissement critique afin d'éviter toute sonnerie.

La précision de l'étalonnage du temps et de la tension est supérieure à 5% mais une onde intérieure d'étalonnage d'une précision de 1% permet la vérification à tout moment.

Un tube à extrémité plate de 4 pouces de diamètre est utilisé avec commande astigmatique, cependant que le micromètre est muni d'éclairage variable, ce qui facilite la mesure rapide et exacte.

EE 15 752 *pour plus amples renseignements*

SECTIONS À FENTES DE GUIDE D'ONDES

(Illustration à la page 698)

Distributeurs: Leland Instruments Ltd, Abbey House, Victoria Street, London, S.W.1.

Ces instruments, qui sont fabriqués par la Société Polytechnic Research Development Co. de New-York, permettent des mesures précises d'ondes stationnaires et d'impédance dans une gamme d'hyperfréquences allant de 2,6 à 40 kHz par seconde. On peut les utiliser tant pour les essais de construction que pour ceux de service, afin d'obtenir le taux d'ondes stationnaires et les données de phase sur les composantes de guide d'ondes. Ils peuvent être employés aussi, conjointement avec des dispositifs d'accord, pour éliminer les désaccords de lignes de transmission. En outre, ils peuvent servir de pièces permanentes de radar pour vérifier les caractéristiques de réflexion de l'antenne. La gamme de fréquences est 'couverte' par huit formats de guides d'ondes standard.

La section à fente consiste en une longueur de guide d'ondes, usinée avec précision à partir d'un bloc de métal solide, avec une étroite fente longitudinale au centre de la paroi supérieure. Un chariot est prévu pour le déplacement de la sonde de captage le long de la fente. Ce chariot est porté par trois roulements à billes, roulant sur pistes cannelées, durcies et minutieusement meulées, fixées sur le corps même de la section. Le mouvement du chariot peut être réglé par rapport au corps principal de façon à ce que le bout de la

sonde suive parallèlement la surface intérieure du guide d'ondes.

Les chariots de sonde ont été calculés pour un mouvement régulier et sûr, sans saccades ou jeu. L'absence de contacts glissants réduit l'usure au minimum et l'instrument garde sa précision indéfiniment.

Afin d'assurer l'exactitude des mesures de phase, chaque section à fentes est munie d'une échelle centimétrique vernier qui indique la distance entre la sonde et l'extrémité extérieure. La course de la sonde couvre, à peu près, une longueur d'onde du guide, à la plus basse fréquence dans chaque gamme, sauf dans les deux lignes de fréquence inférieures où elle couvre les trois-quarts d'une longueur d'onde. Les dimensions intérieures du guide d'ondes sont observées avec précision afin de fournir un étalon d'impédance. Les extrémités des fentes sont diminuées en vue de réduire le taux d'ondes stationnaires résiduel à moins de 1,01, sauf dans les deux lignes de fréquence inférieures où le discontinuité est insignifiante.

EE 15 753 *pour plus amples renseignements*

PONT DE CONDUCTIVITÉ

(Illustration à la page 699)

A. M. Lock & Co. Ltd, Prudential Buildings, 79 Union Street, Oldham, Lancashire

Le pont de conductivité portatif LOCK Type BC1 met en oeuvre les tout derniers circuits à transistors et les techniques de construction les plus récentes afin de garantir un fontionnement sans panne et de longue durée en toutes circonstances. Il est logé dans un coffret en bois dont les dimensions extérieures sont d'environ 305 mm × 190 mm × 140 mm et il est fourni complet avec cellule de conductivité du type à immersion.

La simplicité de fonctionnement et de lecture est assurée par des commandes judicieusement disposées et clairement indiquées sur le panneau incliné avant. Un couvercle de bois facilement rabattable protège l'appareil pour les besoins momentanés. En cours d'emploi, on l'enlève complètement.

Le pont de mesure à courant alternatif BC1 est alimenté à un faible potentiel par un oscillateur à transistors de 1,5 kHz. Cette haute fréquence est utilisée pour éviter les erreurs qui pourraient se produire autrement avec des solutions à haute conductivité.

Durant l'emploi, l'équilibre de pont est indiqué par une déviation maximum du compteur indicateur. La conductivité de la solution est ensuite lue sur un grand cadran étalonné. Grâce à l'utilisation de la méthode du point d'équilibre, les variations de tension de la batterie ou des caractéristiques des transistors n'affectent pas la précision de la mesure.

L'appareil a une portée de mesure s'étendant de 0,5 micromhos à 1 × 166 micromhos en six gammes.

Il convient à l'emploi avec presque tous les modèles de cellules de conductivité. Si la constante de la cellule n'est pas l'unité, on obtiendra la conductivité effective d'une solution en multipliant la lecture du pont par la constante de la cellule.

La compensation de température manuelle dans la gamme de 5 à 35°C est obtenue dans les gammes 2 et 3 à raison de 2%/0°C. Le facteur de correction s'applique à certains condensés et à certaines eaux non traitées, ainsi qu'à presque toutes les solutions aqueuses dont les valeurs de conductivité vont de 5 à 1000 micromhos.

Dans d'autres gammes, le compensateur de température n'est pas branché car la correction nécessaire varie selon la composition et la concentration de l'électrolyte.

Un condensateur variable incorporé équilibre la cellule et le câble de capacité qui donneraient, autrement, un point de compensation plat.

EE 15 754 *pour plus amples renseignements*

ÉLECTROMÈTRE À LAME VIBRANTE

(Illustration à la page 699)

Ekco Electronics Ltd, Southend-on-Sea, Essex.

L'électromètre à lame vibrante type N616 a été conçu pour la mesure de courants continus très faibles et de tensions à haute stabilité O. L'entrée de courant continu est transformée en courant alternatif au moyen d'un condensateur à lame vibrante et elle est amplifiée par un amplificateur de courant alternatif stable.

Sept gammes ont été prévues: 3, 10, 30, 100 et 300 mV, ainsi que IV et 3V. La sortie est redressée et mesurée sur un enregistreur à panneau de 13 cm, étalonné pour l'indication de la tension c.c. à l'entrée.

Pour les mesures de tension, la précision est à peu près de ± 5%, les mesures de courant pouvant être effectuées avec le même degré de précision, à condition de connaître la valeur totale de la résistance d'entrée et de régler la commande d'étalonnage lorsque cela est nécessaire.

EE 15 755 *pour plus amples renseignements*

GÉNÉRATEUR DE FONCTIONS NON-LINÉAIRES

(Illustration à la page 699)

The Solartron Electronic Group Ltd, 45 Thames Street, Kingston, Surrey.

La Société Solartron vient d'annoncer la réalisation du Générateur de fonctions à diodes Type TR829. De format standard, cet appareil a été étudié pour produire des fonctions précises allant d'un degré variable à un haut degré d'exactitude et de stabilité. Il s'ajoute à la série existante de calculateurs analogiques Solartron.

La fonction requise est produite en 12 segments, obtenus simplement en ajustant des points d'interruption pour chaque segment en fonction d'un contrôleur de voltmètre numérique. Ces ajustages s'effectuent avec des potentiomètres hélicoïdaux à haute résolution, dans la gamme de tensions 0 à plus ou moins de 100V. On peut employer conjointement, si l'on veut, deux appareils TR829 pour des fonctions plus compliquées.

Le générateur de fonctions à diodes englobe au total 14 amplificateurs c.c. à grand gain et ne nécessite pas d'amplificateurs de fonctionnement supplémentaires pour fournir un plein rendement. Les erreurs de dérive et de gain pour chaque segment sont retenues à l'intérieur de 100 mV et de 0,2% respectivement, et, puisque ces erreurs ne sont pas cumulatives dans toute la fonction produite, la stabilité générale à long terme est toujours supérieure à 0,5% en moyenne.

EE 15 756 *pour plus amples renseignements*

TRANSDUCTEUR À TRANSFORMATEUR DIFFÉRENTIEL

(Illustration à la page 699)

James Scott & Co. (Electrical Engineers) Ltd, 68 Brockville Street, Carntyne Industrial Estate, Glasgow, E.2.

Dans l'appareil de base LINTRAN, l'entrée est constituée par le mouvement d'un axe, tandis que la sortie électrique est absolument proportionnelle à ce mouvement. Il n'est, cependant, pas limité à cette seule fonction, puisque, par l'adjonction d'un soufflet étalonné, il devient un manomètre. En fait, n'importe quelle quantité dans laquelle un changement peut être traduit en un mouvement, peut être mesurée avec précision au moyen de cet appareil.

Le LINTRAN utilise le principe bien connu du transformateur différentiel. Ce dernier a deux bobinages espacés avec précision par rapport à un bobinage central, de sorte que les signaux des bobinages sont égaux. Si l'on insère une armature métallique dans ces bobinages, le mouvement de cette armature provoquera des changements des champs magnétiques et les sorties ne seront plus égales. Par une construction minutieuse, on pourra rendre la différence de sortie étroitement proportionnelle au déplacement de l'armature de sa position centrale. La différence de sortie est normalement indiquée par un appareil de lecture qui pourra être gradué directement en fonction du mouvement de l'armature. On pourra faire varier, dans cette construction, la grandeur de l'armature insérée et, selon cette grandeur, on obtiendra sur l'appareil de lecture une indication du mouvement de grandeur naturelle, pour un mouvement de l'axe d'entrée pouvant se réduire à un millième de pouce ou s'élever à un pouce.

Les transducteurs antérieurs utilisant le dispositif à transformateur différentiel avaient tendance à être trop grands et encombrants lorsqu'ils étaient destinés à l'usage d'un secteur normal. Ou bien alors, il fallait leur ajouter des circuits électroniques coûteux pour obtenir la sortie précise voulue. Le LINTRAN, en revanche, tout en ayant été étudié pour le fonctionnement sur secteurs normaux, a gardé les avantages d'une grandeur réduite et d'une sortie précise.

L'appareil de base a 184,15 mm de long par 44,5 mm de diamètre et il ne pèse que 907 grammes.

EE 15 757 *pour plus amples renseignements*

BLOC D'ALIMENTATION À BASSE TENSION

(Illustration à la page 700)

Allied Electronics Ltd, 28 Upper Richmond Road, Putney, S.W.15.

Le bloc d'alimentation LS 353-H est destiné à l'emploi dans les cas nécessitant une source compacte de courant continu stabilisé, tels que pour l'alimentation de chauffage d'amplificateurs c.c., pour les lampes d'excitation d'instruments de mesure photoélectriques ainsi que pour les autres applications où l'on emploie généralement des batteries.

L'élément de base est un circuit redresseur à jonction au germanium avec stabilisateur de tension à transistors et dispositif potentiel de référence.

Le système précité dérive des chargeurs de potentiel constant 'ALTRON' fournis à l'usage des accumulateurs hermétiquement scellés au mercure-cadmium 'DEAC'. Les chargeurs 'DEAC' sont livrables pour une gamme de tensions comprise entre 1,5V et 24V et pour des courants de 100A ou davantage.

Le circuit assure un haut degré de stabilisation contre les changements de tension d'entrée ainsi qu'une faible composante ondulée. Une commande préréglée permet de varier la tension d'entrée dans une petite gamme.

Les blocs d'alimentation sont fournis soit sous forme de châssis soit en coffrets.

EE 15 758 *pour plus amples renseignements*

TACHOMÈTRE SENSIBLE AUX CAPACITÉS

(Illustration à la page 700)

Grunther Instruments Ltd, 14 Oriental Street, London, E.14.

Ce tachomètre sensible aux capacités a été conçu à partir d'un projet pour la mesure de vitesses de turbines à gaz allant jusqu'à 120.000 tours/minute dans des températures locales atteignant 700°C.

L'appareil utilise un palpeur placé près—mais non en contact—de toute irrégularité sur une pièce rotative, tournant à la vitesse qui doit être mesurée ou à un multiple ou sous-multiple de cette vitesse. Cette irrégularité peut être une mortaise, un ergot, une came, une dent d'engrenage, un grand écrou hexagonal, ou bien encore un trou ou une saillie n'ayant pas moins de 1,5 mm de diamètre ou de profondeur.

Chaque fois qu'une irrégularité (saillie ou dépression) passe près du palpeur, il se produit un changement de capacité. Ceci provoque une impulsion de tension qui est transmise, au moyen d'un câble flexible de faible diamètre, à l'instrument de comptage pouvant se trouver à quelques centaines de mètres de distance du palpeur.

Le tachomètre proprement dit est un instrument de comptage électronique utilisant une technique longuement éprouvée. L'indicateur est un appareil de mesure à cadre mobile étalonné directement en tours/minute. Il comporte six gammes de lecture permettant, par l'emploi de facteurs de correction en certains cas, d'effectuer des mesures allant de moins de 50 tours/minute à 200.000 tours/minute, avec une précision supérieure à 2% de déviation totale.

Le palpeur, quoique sensible aux changements de capacité, n'est pas affecté par des extrêmes de température, par les vibrations ou la présence d'huiles, etc.

EE 15 759 *pour plus amples renseignements*

ALIMENTATION À DOUBLE BASSE TENSION STABILISÉE

(Illustration à la page 700)

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex.

Le bloc P.P.3 comporte deux sections transistorisées d'alimentation en courant continu stabilisé, de 0 à 30V 1A, contenues dans un coffret fonctionnant à partir d'un transformateur de secteur ordinaire. Les deux sections sont flottantes et peuvent être utilisées séparément, soit reliées en série pour donner une sortie maximum de 60V à 1A, soit pour donner simultanément des tensions positives et négatives (30V max, chacune).

Chaque section couvre une gamme de 0 à 30V en trois étapes se chevauchant de 10V, avec la commande variable étalonnée directement en volts. En outre, l'instrument comprend un voltmètre et un ampèremètre qui peuvent être branchés indépendamment sur chaque section, l'ampèremètre étant à deux gammes.

Quatre réseaux de sortie aux bornes permettent d'éliminer virtuellement la résistance des conducteurs de connexion à la charge.

Le disjoncteur à maxima est constitué par un circuit électronique assurant une protection totale contre les surcharges progressives ou soudaines (court-circuit). Ce circuit électronique peut être réenclanché à partir du panneau avant au moyen de l'interrupteur arrêt-marche. Enfin, grâce à un fusible monté sur panneau, dans le circuit de secteur, l'instrument est protégé contre toute panne intérieure ou surtension de secteur.

EE 15 760 *pour plus amples renseignements*

OSCILLOSCOPE DE CONTRÔLE D'IMPULSIONS

(Illustration à la page 700)

Mullard Equipment Ltd, Mullard House, Torrington Place, London W.C.1

La Société Mullard vient de réaliser un nouveau modèle bon marché d'oscilloscope de contrôle d'impulsions, avec temps de montée rapide de 2 mμsec, équivalent à une largeur de bande allant du courant continu à 220 MHz.

Cet appareil, qui porte la désignation L.362, a été étudié pour la présentation ou la mesure d'impulsions d'une durée de 3 mμsec à 3 μsec, et il sera donc des plus utiles pour les travaux de recherches nucléaires et de calcul électronique ainsi que pour l'examen d'impulsions de radar, particulièrement en ce qui concerne les appareils à portée réduite et à haute résolution.

En plus de sa largeur de bande très étendue, le Modèle L.362 comporte plusieurs autres avantages d'importance. Ainsi, sa sensibilité est de 150 mV/cm ce qui, ajouté à ses amplificateurs à couplage direct, le rend particulièrement indiqué pour les travaux sur les circuits à transistors. Le palpeur d'entrée est compact, aisément maniable, et la charge qu'il impose sur le circuit en cours de contrôle n'est que de 2 pF. L'instrument permet aussi la représentation d'impulsions de forme identique à séparation intermittente, telles que celles qui se produisent, par exemple, dans les détecteurs nucléaires. De plus, les images d'impulsions courtes à fréquence réduite, peuvent être présentées fort clairement. Enfin, grâce, à l'utilisation étendue de transistors, le L.362 est un instrument portatif des plus compacts.

Conçu d'après un dessin des Etablissements de Recherches Atomiques de Harwell, le L.362 applique le principe discriminateur ou "d'échantillonnage", l'oscillogramme entier étant formé, en tant que reproduction à basse fréquence de l'entrée, d'une série de points dont chacun correspond à un "échantillon" pris des répétitions successives de l'entrée. Un circuit d'accumulation de charge maintient la position du point jusqu'à ce que l'échantillon suivant soit pris. Le faisceau cathodique demeure, ainsi, en circuit, dans la plupart des cas, pendant 80% environ de la durée du cycle, et on obtient une image de forte brilliance sans accélération de post-déviation.

Le comparateur et les circuits d'accumulation de charge X et Y constituent le centre fonctionnel de l'appareil. La sortie du circuit d'accumulation X est comparée avec une forme d'onde de base de temps des générateurs à balayage rapide, et lorsque leurs valeurs sont égales, le comparateur produit une impulsion qui déclenche les circuits de prise d'échantillons. Une impulsion est transmise, au même moment, au circuit d'accumulation de charge X, réduisant ainsi la charge accumulée. L'impulsion de déclenchement d'échantillonnage se produit donc relativement plus tôt et les points cathodiques se déplacent à gauche au cours des répétitions successives de la forme d'onde d'entrée. Lorsque la charge accumulée tombe à un niveau prédéterminé, le circuit est réenclanché et le retour du spot se produit.

L'entrée devant être représentée est appliquée au circuit d'échantillonage qui se trouve dans un petit palpeur à part. La tension d'entrée charge la capacité d'entrée de l'appareil, et lorsque l'impulsion de déclenchement d'échantillonnage a été reçue, cette charge est renvoyée, à travers l'amplificateur de charges, à l'élément d'accumulation de charges Y. La charge accumulée est donc proportionnelle à la tension d'entrée au moment de l'échantillonnage.

Une seconde impulsion du circuit X est transmise à l'élément d'accumulation de charges Y et la tension correspondant à la charge accumulée est ensuite appliquée, par le truchement de l'amplificateur de déviation Y, aux plaques Y

du tube cathodique. Le circuit d'accumulation de charges X produit également des impulsions qui suppriment le faisceau du tube pendant que le spot se déplace.

Une seconde entrée d'impulsions de déclenchement, qui doit précéder le signal d'entrée de 0,05 à 2 μsec, est appliquée au retardateur de déclenchement, puis au générateur à balayage rapide qui produit la forme d'onde de base de temps appliquée au comparateur.

EE 15 761 *pour plus amples renseignements*

BLOC D'ALIMENTATION CONVERTISSEUR D'IMAGE

(Illustration à la page 701)

Sionic Ltd, Cromwell House, 93 Wood End Green Road, Hayes, Middlesex.

Le bloc d'alimentation stabilisée type 359A a été étudié pour la commande des tubes convertisseurs d'images MULLARD.

L'élément à bobine de focalisation de courant stabilisé fournit 200 à 500 mA pour une charge nominale de 700 ohms. Un changement de charge de ± 100 ohms donne un changement de courant de 1%. L'ondulation est inférieure à 50 μA, tandis que l'entrée secteur et la stabilité de température sont supérieures à 1%.

L'élément d'alimentation très haute tension fournit de 5 à 14,5 kV, à 1 μA, avec prise d'alimentation de grille pouvant donner 1 μA. Sans l'alimentation de grille, le courant disponible est de 100 μA. L'ondulation est inférieure à 1V de crête à crête et la stabilisation globale est supérieure à 2%.

EE 15 762 *pour plus amples renseignements*

FICHES ET PRISES MINIATURE

(Illustration à la page 701)

Harwin Engineers Ltd, Rodney Road, Portsmouth, Hampshire.

La fiche avec prise Harwin W.300/3001, de format extrêmement réduit et en nylon, peut être montée entre pointes de 4,7625 mm seulement. Elle est munie de contacts dorés pouvant porter une tension atteignant 7,5A à 750V. La résistance de contact est en moyenne de 2 mΩ et l'isolement est supérieur à 10^6Ω. Des conditions de fonctionnement allant jusqu'à 100°C peuvent être tolérées et la résistance aux chocs et aux vibrations est, semble-t-il, excellente.

EE 15 763 *pour plus amples renseignements*

CADRANS NUMÉRIQUES "EN LIGNE"

(Illustration à la page 701)

Amphenol (Great Britain) Ltd, Ormond House, 26/27 Boswell Street, London, W.C.1.

On sait que la lecture et le réglage rapides des cadrans sont la cause d'erreurs de lecture et il a été établi que pour obtenir des valeurs numériques précises, la présentation numérique dite "en ligne" garantit le plus haut degré d'exactitude lorsqu'une lecture et un réglage rapides sont nécessaires.

Ces constatations ont conduit à la réalisation des microcadrans de la série Borg 1300. Afin de tirer le maximum d'avantages de la présentation numérique en ligne, les chiffres font contraste direct avec le fond, étant, par exemple, en blanc sur fond noir ou en noir sur fond blanc. Une grande fenêtre courbe et scellée offre un grand angle de vision. Afin de garantir le maximum de sensibilité et de précision, le bouton de réglage est monté directement sur l'axe. Tout jeu pouvant résulter de l'engrenage est donc éliminé.

Il existe des modèles avec frein de bout de dogt pour maintenir les réglages en cas de chocs ou vibrations. Les modèles livrables sont comme suit:

Modèle 1307: cadran à trois numéros, comptant de 0 à 999, en dix tours du bouton de réglage et muni de frein de bout de doigt.

Modèle 1308: comme le précédent, mais sans frein de bout de doigt.

Modèle 1304: cadran à quatre numéros, comptant de 0 à 9999 en 100 tours.

Modèle 1305: cadran à cinq numéros, comptant de 0 à 99999 en 1000 tours.

EE 15 764 *pour plus amples renseignements*

GÉNÉRATEUR DE SIGNAUX POUR HYPERFRÉQUENCES

(Illustration à la page 701)

Airmec Ltd, High Wycombe, Buckinghamshire.

Le générateur de signaux hyperfréquences type 204 est venu s'ajouter depuis peu à l'assortiment d'instruments électroniques fabriqués par la Société Airmec Limited.

Sa plage de fréquences s'étend de 1 MHz à 320 MHz sur 5 gammes. La fréquence employée est indiquée sur une échelle à film lumineux d'une longueur de 121.9 cm pour chaque gamme, cependant qu'un oscillateur à cristal de contrôle, incorporé à l'instrument, assure la précision absolue de l'étalonnage.

Une des caractéristiques les plus remarquables du générateur type 204 est constituée par la stabilisation du niveau de sortie à n'importe quelle valeur comprise entre 2μV et 220 mV, ce qui rend inutile le contrôle fastidieux et le recalage de la sortie lorsqu'on emploie un nombre de fréquences différentes.

Un oscillateur interne de 1 kHz a été prévu pour la modulation d'amplitude ou de fréquence. On peut contrôler, avec un compteur incorporé, une profondeur de modulation allant jusqu'à 5% ou une déviation atteignant 80 kHz, jusqu'à ± 5% de précision. On peut aussi appliquer une modulation extérieure, soit séparément, soit en même temps que la modulation intérieure, à n'importe quelle fréquence comprise entre 30 Hz et 15 kHz. Enfin, on peut également appliquer une modulation d'impulsions extérieures à des fréquences de répétition d'impulsions allant de 30 Hz à 50 kHz.

L'appareil est muni d'un atténuateur à plots de 52 ohms à impédance constante, tandis qu'un câble d'adaptation transforme l'impédance de source à 75 ohms lorsque cela est nécessaire.

EE 15 765 *pour plus amples renseignements*

Résumés des Principaux Articles

Un système de commutation statique utilisant des tubes à cathodes froides (Système AUSTIN de commutation électronique à cathodes froides) par R. W. Brierley

Résumé de l'article aux pages 646 à 654

L'automatisation très poussée des procédés de production qui s'effectue actuellement a donné lieu à des systèmes de commande fort compliqués. La plupart de ces systèmes sont du type marche/arrêt, utilisant des relais comme éléments logiques.

A partir d'un certain degré de complexité, il devient difficile de maintenir un niveau élevé d'efficacité de fonctionnement avec ces équipements. On a donc cherché des variantes plus sûres du relais électro-mécanique, ce qui a amené la réalisation, depuis peu, de systèmes à dispositifs statiques. Un de Ces systèmes, utilisant des tubes à cathodes froides, est décrit dans cet article.

Un enregistreur vectoriel par K. G. Freeman

Résumé de l'article aux pages 655 à 658

Le Vectorscope dont il est question dans cet article donne une image vectorielle des signaux de chrominance du type dit NTSC. C'est un appareil des plus sensibles, comportant un nombre d'éléments fort utiles permettant, entre autres, une vérification continue du gain, ainsi que des réglages de quadrature. Grâce au Vectorscope, on peut évaluer rapidement les caractéristiques de phase et d'amplitude de signaux de chrominance, qui sont d'une importance particulière pour le décodage direct des tubes à rayons cathodiques pour télévision en couleur à canon de signalisation.

Semi-conducteurs composés par D. A. Wright

Résumé de l'article aux pages 659 à 665

L'auteur examine. en premier lieu, les principaux paramètres régissant le comportement des semi-conducteurs. Ces considérations sont, ensuite, appliquées aux différents types de semi-conducteurs composés conçus à ce jour et elles sont complétées par des données de valeurs de paramètres moyens. L'utilité des matériaux pour différentes applications est analysée à la lumière de ces chiffres. Pour chaque type de semi-conducteur composé, certaines tendances bien définies ont été observées dans le rapport entre paramètres de semi-conducteurs et autres propriétés physiques. Ces tendances sont définies par l'auteur, qui en indique leur interprétation. Il mentionne brièvement les paramètres d'importance pour les applications thermoélectriques et rappelle, en conclusion, que le choix des matériaux pour ces usages dépend précisément des paramètres cités au début.

Indicateurs de rapport d'amplitude de tension à lecture automatique par M. Kollanyi et R. M. Verran

Résumé de l'article aux pages 666 à 671

Un indicateur automatique donnant une lecture directe, soit sur enregistreur, soit sur appareil à image numérique, peut remplacer avantageusement l'indicateur classique de rapport d'amplitude de tension dont les réglages prennent du temps. Les circuits peuvent être utilisés avec n'importe quelle ligne rainurée ou dispositif équivalent. Un simple mouvement du chariot à sonde est tout ce qu'il faut pour que l'instrument donne une lecture correcte du rapport d'amplitude de tension.

Le système décrit dans cet article est basé sur un détecteur maximum/minimum qui relève les valeurs extrêmes de tension rencontrées durant le cycle d'enregistrement. Le rapport de ces tensions peut être calculé par diverses méthodes électroniques qui sont également décrites.

Une valeur résiduelle de rapport d'amplitude de tension de $<1{,}5$ peut être obtenue avec une portée maximum de 1 : 3 ou davantage, si nécessaire, quoique cette portée dépende de la méthode choisie.

Les tubes à gaz en tant que générateurs de musique par Alan Douglas

Résumé de l'article aux pages 672 à 673

L'attrait évident que présente l'emploi de deux tubes à gaz à électrodes comme oscillateurs à relaxation semblerait indiquer que de nombreux problèmes de production de musique électrique pourraient être ainsi résolus économiquement. En réalité, toutefois, aucun instrument commercial n'utilise pareils dispositifs. Certains circuits récents tirent le meilleur effet possible des limites physiques inhérentes aux tubes à gaz non coûteux.

Un système de modulation en triangle à transistors à jonction par B. E. Williams

Résumé de l'article aux pages 674 à 680

Description d'un système de modulation en triangle fonctionnant à une fréquence numérique de 14 kHz et fournissant un lien simple de parole d'une intelligibilité parfaite. L'appareil n'a qu'une seule commance manuelle, soit un bouton-poussoir pour parler, les autres réglages étant préréglés ou s'effectuant automatiquement. Le récepteur régénère le signal capté, par tension et "découpage" de temps, avant de le transmettre au décodeur. L'appareil fonctionne de façon pleinement satisfaisante dans une gamme étendue de températures ambiantes et il convient à l'emploi dans des lignes égalisées ou dans des chaînes de stations-radio. L'alimentation nécessaire à l'appareil est de 6 à 12 volts.

Un petit bloc d'alimentation réglée haute tension avec sortie variable par J. D. O'Toole

Résumé de l'article aux pages 681 à 683

Les champ des applications pour l'alimentation h.t. à sortie stable, n'exigeant pas une puissance élevée, s'étend constamment. Il semble, cependant, que la demande dans ce domaine n'ait été qu'imparfaitement satisfaite, en raison, vraisemblablement, d'une certaine insuffisance en ce qui concerne les petites lampes actuelles. L'auteur décrit ici un circuit de base qui obvierait à cette apparente inaptitude, ainsi qu'un circuit-type de ce genre, dont il indique les chiffres de rendement.

Un système pour fournir une tension vectorielle précise par D. J. Collins et J. E. Smith

Résumé de l'article aux pages 684 à 685

Dans de nombreux domaines de l'électronique, on a souvent besoin de produire une tension de phase et d'amplitude connues, se rapportant à quelque niveau de référence. Abstraction faite des dispositifs électro-mécaniques, la précision avec laquelle cette tension est produite dépend dans une grande mesure de la précision des composantes du déphaseur. Cet article traite d'un système pouvant produire une tension vectorielle précise, dont l'amplitude, quelle qu'elle soit, est inférieure au niveau de référence et dont le rapport de phase est de 0° à 360°. Un pareil système est de grande utilité pour l'étalonnage des déphaseurs et des appareils de mesure de phase.

Une autre méthode pour comparer les propriétés électriques des résines de moulage en époxie par D. H. Thompson

Résumé de l'article aux pages 686 à 687

Cet article décrit une méthode pour évaluer la constante diélectrique, les pertes et la résistivité de volume des résines de moulage d'époxie dans une gamme de températures étendue et pour des fréquences allant jusqu'à 5 MHz.

Cette méthode de mesure s'effectue aux dépens de la précision absolue réduite lorsqu'on la compare avec la méthode courante de Hartshorn et Ward. Si, par contre, on l'emploie essentiellement pour comparer des résines et pour évaluer la stabilité de température de leurs paramètres électriques, elle mérite alors un usage plus répandu.

En particulier, des valeurs absolues peuvent être citées avec cette méthode, à condition qu'on prenne soin de vérifier ou de normaliser les résultats aux températures de laboratoire.

Un régulateur basse tension transistorisé par J. H. Deichen

Résumé de l'article aux pages 688 à 689

Cet article traite des méthodes d'alimentation en courant continu stabilisé pour réchaffeurs à lampes et discute leurs limites. Il indique ensuite, un circuit simple utilisant un transistor et deux diodes Zéner dont il décrit la conception et les performances.

ELEKTRONISCHE GERÄTE

Beschreibung neuer Bauelemente, Zubehörteile und Prüfgeräte auf Grund der von Herstellern gemachten Angaben. *Übersetzung der Seiten 698 bis 671*

STABILISIERTES NETZGERÄT

(Abbildung Seite 698)

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

Advance stellt für Sonderzwecke ein stabilisiertes Netzgerät Typ L 101 grosser Anpassungsfähigkeit her, das eine konstante Spannungsquelle für +600 V und zwei stabilisierte Leitungen für −150 V Gleichstrom hat. Eine der stabilisierten Leitungen ist variabel und hat eine Quelle hoher Impedanz. Zwei Anschlüsse für 6,3 V 4 A stabilisierten Wechselstrom sind auch vorhanden.

Eine stabilisierte, variable, negative Leitung für 0—150 V mit hoher Quellenimpedanz ist für Gittervorspannung und andere Kreise bestimmt, die nicht mehr als 5 mA entnehmen. Für allgemeinen Bedarf ist ein unstabilisierter Ausgang von 100—800 V vorgesehen.

Höchstbelastung für die beiden positiven Leitungen ist zusammen 300 mA. Der +600 V und der −150 V Ausgang können seriengeschaltet als stabilisierter Ausgang von 750 V Gleichstrom für 30 mA Höchstbelastung Verwendung finden.

Für 10% Änderung der Eingangsspannung sind die Spannungsabweichungen der +600 V und −150 V Leitungen geringer als 0,03%. Die Ausgangsschwankungen der beiden 6,3 V Wechselstromleitungen sind unter denselben Bedingungen geringer als 0.02 V.

Die Ausgangsimpedanz für alle Gleichstromleitungen ist bei Gleichstrom unter 0,1Ω und bei 50 kHz unter 0,5Ω. Die Quellenimpedanz der von 0 bis 150 V variablen negativen Leitung ist 12 kΩ. Für stabilisierte Ausgänge bis zu 150 V ist die Effektiv-Restwellenspannung unter 3 mV. Über 150 V ist die Restwellenspannung unter 0,002% eff und für den unstabilisierten Gleichstrom zwischen 100 und 800 V ungefähr 3 V eff, gemessen bei 800 V und 300 mA.

Es ist möglich, die stabilisierte Hochspannungs-Gleichspannung auf jeden gewünschten Pegel zwischen 0 und 600 V einzustellen, wobei gleichzeitig der Quellenwiderstand über den Bereich 0—40Ω regelbar ist. Eine von 0—6 V eff variable Brummspannung kann dem stabilisierten Hochspannungsgleichstrom überlagert werden, um eine hochwertige Sinuswellenform entsprechend der Eingangsnetzfrequenz zu erhalten.

Alle Ausgänge sind in Bezug auf das Chassis erdfrei. Die positiven und negativen Leitungen sind durch eine neutrale Klemme verbunden.

EE 15 751 *für weitere Einzelheiten*

IMPULS-OSZILLOGRAF

(Abbildung Seite 698)

Furzehill Laboratories Ltd, 57 Clarendon Road, Watford, Hertfordshire

Der Furzehill Oszillograf Modell O-140 ist nunmehr in laufender Produktion und ermöglicht Impuls- und HF-Untersuchungen mit geringem Geldaufwand. Der Ablenkteil kann entweder für Triggerung oder Dauerbetrieb im Bereich 0,1 μs/cm ... 0,5 s/cm benutzt werden. Nützlich ist die Feineinstellung der Triggerung, die es ermöglicht, die horizontale Bestreichung an jedem gewünschten Punkt der zu untersuchenden Wellenform zu beginnen. Bei wiederholter Einstellung findet positive und sofortige Synchronisierung durch einen getrennten Synchronisierungsverstärker statt, der entweder von einem eingebauten Verstärker oder einer Fremdquelle gespeist wird.

Der Ablenkverstärker ist direkt gekuppelt und hat acht Empfindlichkeitsstufen: 50, 15, 5, 1,5, 0,5 und 0,15 V/cm bis 10 MHz und zusätzlich 50 mV/cm bis 3,3 MHz und 15 mV/cm bis 1 MHz. Da das Gerät zur Untersuchung von Impulsen entwickeit wurde, sind die Verstärker zur Vermeidung von Eigenerregung kritisch gedämpft.

Die Eichgenauigkeit für Zeit und Spannung ist besser als 5%, kann aber jederzeit gegen eine eingebaute Eichwellenform mit 1% iger Genauigkeit geprüft werden.

Eine 10cm Elektronenstrahlröhre mit flachem Schirm und Anastigmatkorrektur findet Verwendung. Zur Erzielung schneller und genauer Messungen ist die Rasterskalenbeleuchtung variabel.

EE 15 752 *für weitere Einzelheiten*

HOHLLEITERSTÜCKE MIT SCHLITZ

(Abbildung Seite 698)

Vertrieb durch: Leland Instruments Ltd, Abbey House, Victoria Street, London, S.W.1

Diese von Polytechnic Research Development Co. in New York hergestellten Vorrichtungen ermöglichen genaue Messungen stehender Wellen und Impedanzen im Mikrowellenbereich von 2,6 ... 40 GHz. Sie können sowohl für Entwicklungsarbeiten, als auch für laufende Überprüfung der Stehwellenverhältnisse und Phasendaten von Hohlleiter-Bauelementen oder mit Abstimmvorrichtungen zur Vermeidung von Falschanpassungen in Leitungen Verwendung finden. Ausserdem können sie als festeingebaute Elemente zur Überprüfung von Antennenreflexionskennlinien in Radar- und Nachrichtensystemen benutzt werden. Der Frequenzbereich wird durch acht Standard-Leitungsstücke überstrichen.

Das Leitungsstück mit Schlitz besteht aus einem aus Vollmetall sorgfältig hergestellten Hohlleiter mit einem engen Längsschlitz in der Mitte der oberen Wand. Ein Schlitten bewegt den Messkopf über die ganze Länge des Schlitzes. Dieser Schlitten läuft auf drei Kugellagern, die auf gehärteten und mit grosser Genauigkeit geschliffenen Bahnen laufen, die ihrerseits an dem Gerätekörper angebracht sind. Die Schlittenbewegung kann in Bezug auf den Gerätekörper so geregelt werden, dass der Messkopf sich genau parallel zur Innenoberfläche des Hohlleiters bewegt.

Die Schlittenkonstruktion führt zu glattem und genauem Abtasten ohne toten Gang oder Spiel. Die Abwesenheit von Schleifkontakten reduziert die Abnutzung zu einem Minimum. Dadurch wird die Gerätegenauigkeit auf die Dauer erhalten.

Zur Ausführung genauer Phasenmessungen ist jedes Leitungsstück mit Schlitz auch mit einer Zentimeterskala für Feineinstellung versehen, auf der der Abstand zwischen Messkopf und dem Aussenende abgelesen werden kann. Die Länge des Messkopfdurchganges ist für die niedrigste Frequenz jedes Bereiches

ungefähr eine Hohlleiterwellenlänge, mit Ausnahme der beiden Leitungsstücke für die niedrigsten Frequenzen, für die er einer dreiviertel Wellenlänge entspricht. Die Innenabmessungen werden genau eingehalten, um eine genormte Impedanz zu erzielen. Mit Ausnahme der beiden Leitungen für die niedrigsten Frequenzen, bei denen die Diskontinuität vernachlässigt werden kann, sind die Schlitzenden abgeschrägt, um das Reststehwellenverhältnis unter 1,01 herunterzubringen.

EE 15 753 *für weitere Einzelheiten*

LEITFÄHIGKEITSMESSBRÜCKE

(Abbildung Seite 699)

A. M. Lock & Co. Ltd, Prudential Buildings, 79 Union Street, Oldham, Lancashire

Die für die tragbare „Lock" Leitfähigkeitsmessbrücke Modell CB 1 eingesetzten neuesten Transistorschaltungen und Herstellungsmethoden garantieren einen langen, störungsfreien Gebrauch in Labor und Aussendienst. Der aus Holz bestehende Tragkoffer hat Aussenabmessungen von 305 × 190 × 140 mm und enthält das mitgelieferte Eintauch-Leitfähigkeitsgefäss.

Sorgfältige Anordnung und klare Beschriftung der Bedienungsknöpfe machen Einstellung und Ablesen leicht. Der schnell abnehmbare Deckel gibt Schutz beim Transport und wird für den Gebrauch entfernt.

Die Wechselstrommessbrücke wird von einem 1,5 KHz Transistor-Oszillator mit geringem Potential gespeist. Die Wahl der hohen Frequenz vermeidet die sonst durch hohe Leitfähigkeit der Lösungen auftretenden Ungenauigkeiten.

Im Gebrauch tritt der Brückenausgleich beim Höchstausschlag des Anzeigegerätes auf. Die Leitfähigkeit der Lösung wird dann auf einer grossen, geeichten Skala abgelesen. Durch Anwendung dieses Nullverfahrens haben Schwankungen der Batteriespannung oder Transistor-Kennlinien keinen Einfluss auf die Messgenauigkeit.

Das Gerät hat sechs Messbereiche für Messungen von 0,5 bis 1×10^6 micromhos.

Fast alle Leitfähigkeitsgefässe können für diese Brücke Verwendung finden. Falls die Gefässkonstante nicht 1 ist, wird die tatsächliche Lösungsleitfähigkeit durch Multiplikation des abgelesenen Wertes mit der Konstanten erreicht.

Für Temperaturen zwischen 5 und 35°C kann in Messbereichen 2 und 3 ein Ausgleich von 2%/°C manuell eingestellt werden. Dieser Ausgleich genügt für gewisse Kondensate und unbehandelte Gewässer, sowie die meisten wässrigen Lösungen mit Leitfähigkeitswerten von 5 bis 1000 micromhos.

Für andere Bereiche ist der Temperaturausgleich nicht eingeschaltet, da sich die notwendige Korrektur mit der Zusammensetzung und Konzentration der Elektrolyte ändert.

Ein eingebauter Drehkodensator dient dem Ausgleich der Gefäss- und Kabelkapazität zur Vermeidung einer flachen Nullabstimmung.

EE 15 754 *für weitere Einzelheiten*

ZUNGENELEKTROMETER

(Abbildung Seite 699)

Ekco Electronics Ltd, Southend-on-Sea, Essex

Das Zungenelektrometer Type N616 wurde zur Messung sehr kleiner Gleichströme und -spannungen mit grosser Nullstabilität entwickelt. Der Gleichstromeingang wird mittels eines Kondensators mit schwingender Zunge in Wechselstrom umgewandelt und in einem stabilen Wechselstromverstärker verstärkt.

Sieben Messbereiche sind vorgesehen: 3, 10, 30, 100 und 300 mV, 1 und 3 V. Der Ausgang wird gleichgerichtet und auf einem 13 cm Schalttafelinstrument angezeigt, das in Gleichstrom-Eingangsspannung geeicht ist.

Die Genauigkeit für Spannungsmessungen beträgt ± 5%. Dieselbe Genauigkeit kann für Strommessungen erreicht werden, vorausgesetzt, dass die Gesamtgrösse des Eingangswiderstandes bekannt ist und die Eichung dementsprechend nachgestellt wird.

EE 15 755 *für weitere Einzelheiten*

UNGERADLINIGER FUNKTIONSGEBER

(Abbildung Seite 699)

The Solartron Electronic Group Ltd, 45 Thames Street, Kingston, Surrey

Solartron hat vor kurzem den Dioden-Funktionsgeber TR 829 herausgebracht. Der TR 829 erzeugt mit hoher Genauigkeit und Stabilität genaue Funktionen einer Variablen und ist für Einbau in ein 19 Zoll (482,6 mm) Normalgestell konstruiert. Er erweitert das Solartron Fertigungsprogamm für ungeradlinige Analogrechner-Bausteine.

Die gewünschte Funktion wird in 12 Sektoren erzeugt. Die Einstellung für jeden Sektor erfolgt sehr einfach durch Einregelung des Knickpunktes mit Hilfe des Ziffernvoltmeters eines Monitors. Die Einregelung über den Spannungsbereich 0 ... ± 100 V erfolgt mittels eines Heli-Potentiometers hoher Auflösung. Zwei TR 829 Bausteine können zur Erzeugung komplexer Funktionen zusammengeschaltet werden.

Der Dioden-Funktionsgeber enthält insgesamt 14 Hochleistungs-Gleichstromverstärker und benötigt keine zusätzlichen Operationsverstärker für volle Ausgangsleistung. Drift- und Verstärkungsfehler für jeden Sektor werden unter 100 mV bzw. 0,2% gehalten, und da sie nicht kumulativ über die ganze erzeugte Funktion sind, wird die durchschnittliche Gesamtdauerstabilität immer unter 0,5% liegen.

EE 15 756 *für weitere Einzelheiten*

UMWANDLER MIT DIFFERENTIALÜBERTRAGER

(Abbildung Seite 699)

James Scott & Co. (Electrical Engineers) Ltd, 68 Brookville Street, Caratyne Industrial Estate, Glasgow, E.2

Für die Grundform des LINTRAN-Gerätes besteht die Eingabe aus der Bewegung eines Schaftes, der der elektrische Ausgang genau proportional ist. Jedoch ist es nicht auf diese Arbeitsweise beschränkt, da es durch Zusatz von geeichten Balgen als Druckmesser usw. Verwendung finden kann. Tatsächlich eignet sich das Gerät zur Messung jeder Quantität, deren Änderung in Bewegung umgesetzt werden kann.

LINTRAN bringt das bekannte Prinzip des Differentialübertragers zur Anwendung, in dem zwei Wicklungen gegenüber einer Mittelwicklung einen genauen Abstand haben, sodass Signale von beiden Wicklungen gleich sind. Die Bewegung eines Eisenankers innerhalb der Wicklungen ruft Änderungen im inneren magnetischen Feld hervor, und die Ausgänge sind nicht mehr gleich. Bei vorsichtiger Konstruktion können die Ausgangsdifferenzen der Bewegung des Ankers von seiner Mittellage genau proportional gemacht werden. Die Ausgangsdifferenz wird gewöhnlich auf einem Messgerät angezeigt, das direkt in Einheiten der Ankerbewegung geeicht werden kann. In dieser Konstruktion kann die Ankergrösse geändert werden. Es hängt von der Ankergrösse ab, ob das Instrument für eine Schaftbewegung von nur 0,025 mm oder 25,4 mm Vollausschlag anzeigt.

Bisherige, für direkten Netzanschluss konstruierte Umwandler mit Differentialübertrager-Anordnung neigten dazu, gross und umständlich zu sein oder teuere elektronische Kreise zu bedingen, um die geforderte Ausgangsgenauigkeit zu erreichen. LINTRAN arbeitet jedoch mit normalen Netzspannungen, ist klein und hat doch die Ausgangsgenauigkeit beibehalten.

Das Grundgerät ist 184 mm lang und hat einen Durchmesser von 44,5 mm; es wiegt 907 g.

EE 15 757 *für weitere Einzelheiten*

NIEDERSPANNUNGS-NETZGERÄT

(Abbildung Seite 700)

Allied Electronics Ltd, 28 Upper Richmond Road, Putney, S.W.15

Das Netzgerät LS353-H ist eine gedrängt gebaute, stabilisierte Gleichstromquelle für Heizfäden, Belichtungslampen in fotoelektrischen Messgeräten und andere Verwendungszwecke, für die normalerweise Batterien benutzt werden.

Das Grundgerät besteht aus einer Ge-Flächengleichrichterschaltung, einem Transistor-Spannungsstabilisator und einer Bezugsspannungsanordnung.

Das oben beschriebene System ist eine Weiterentwicklung des „Altron" Ladegerätes, das eine konstante Spannung für „DEAC" luftdicht verschlossene Quecksilber-Kadmium-Akkumulatoren liefert.

„DEAC"-Ladegeräte sind für eine Reihe von Spannungen zwischen 1,5 ... 24 V und Stromstärken bis zu 100 A und mehr lieferbar.

Die Schaltung führt zu hochgradiger Stabilisation gegen Schwankungen der Eingangsspannung und geringer Restwelligkeit. Die Ausgangsspannung kann mittels eines Trimmers über einen kleinen Bereich verändert werden.

Die Netzgeräte sind als Chassis oder in Gehäusen lieferbar.

EE 15 758 *für weitere Einzelheiten*

KAPAZITÄTSEMPFINDLICHES TACHOMETER

(Abbildung Seite 700)

Grunther Instruments Ltd, 14 Oriental Street, London, E.14

Dieses kapazitätsempfindliche Tachometer wurde für ein Projekt entwickelt, das Messung von Gasturbinengeschwindigkeiten bis zu 120,000 U/min bei örtlichen Temperaturen bis zu 700° erforderte.

Der benutzte Messkopf wird nahe einer Unebenheit des rotierenden Teiles angeordnet, ohne sie zu berühren. Der Teil kann mit der zu messenden Geschwindigkeit einer mehrfachen oder ganzzahligen Teilgeschwindigkeit laufen. Die Unebenheit kann aus einer Keilnute, Nocke, dem Zahn eines Zahnrades, einer grossen Sechskantenmutter, einem Loch oder Höcker über 1,6 mmϕ und Tiefe bestehen.

Die Kapazität ändert sich jedesmal, wenn die hervorstehende oder eingelassene Unebenheit am Messkopf vorbeigeht. Dadurch wird ein Spannungsimpuls hervorgerufen, der über ein Kabel kleinen Durchmessers einen Zähler speist, der mehrere hundert Meter vom Messkopf entfernt aufgestellt sein kann.

Das Tachometer besteht aus einem elektronischen Zähler bekannter Arbeitsweise. Ein direkt in U/min geeichtes Drehspulinstrument dient als Anzeiger. Sechs Messbereiche ermöglichen Messungen unter 50 U/min ... 200,000 U/min, wobei in gewissen Fällen Korrekturfaktoren benutzt werden. Die Messgenauigkeit ist immer besser als 2% des Vollausschlages.

Der kapazitätsempfindliche Messkopf wird nicht durch übermässige Temperaturen, Schwingungen oder Öl beeinflusst.

EE 15 759 *für weitere Einzelheiten*

STABILISIERTES ZWILLINGS-NIEDERSPANNUNGSNETZGERÄT

(Abbildung Seite 700)

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

Modell P.P.3 besteht aus zwei transistorisierten Netzteilen mit gemeinsamem Netztransformator in einem Gehäuse. Sie geben je 0 ... 30 V 1 A stabilisierten Gleichstrom ab, und da die beiden Teile nicht geerdet sind, können sie entweder getrennt arbeiten oder seriengeschaltet werden, um entweder eine Höchstleistung von 60 V 1 A oder gleichzeitig positive und negative Spannungen (max. je 30 V) abzugeben.

Der Spannungsbereich jedes Teiles von 0 ... 30 V ist in drei überschneidende 10 V-Bereiche unterteilt, deren variable Einstellung direkt in Volt geeicht ist. Eingebaute Volt- und Amperemeter können unabhängig zu jedem Netzteil geschaltet werden. Das Amperemeter hat zwei Bereiche.

Vier Abschlussnetzwerke für den Ausgang ermöglichen den praktischen Ausgleich des Widerstandes der Verbindungsleitungen zur Belastung.

Überlastungsschutz durch eine elektronische Schaltung gibt vollständigen Schutz sowohl gegen anwachsende, als auch Kurzschlussbelastung. Der Kreis kann durch Bedienung des „Ein-Aus"-Schalters auf der Frontplatte wieder hergestellt werden. Schutz gegen Störungen im Gerät und übermässige Netzstromstösse erfolgt durch eine auf der Fronttafel angebrachte Sicherung im Netzstromkreis.

EE 15 760 *für weitere Einzelheiten*

IMPULS-MONITOROSZILLOGRAF

(Abbildung Seite 700)

Mullard Equipment Ltd, Mullard House, Torrington Place, London W.C.1

Der von Mullard Equipment Ltd. eingeführte neue und preisgünstige Impuls - Monitoroszillograf hat eine schnelle Anstiegszeit von 2 ns, die einer Bandbreite von 0-220 MHz entspricht.

Modell L 362 wurde für Darstellung und Messen von Impulsen mit 3 ns bis 3 μs Dauer entwickelt und ist daher für Arbeiten auf dem Kerngebiet und an Rechnern, sowie für Untersuchung von Radarimpulsen für Nahverkehrsanlagen hoher Auflösung besonders wertvoll.

Modell L 362 hat ausser der grossen Bandbreite noch verschiedene, äusserst bemerkenswerte Eigenschaften. Eine Empfindlichkeit von 150 mV/cm eignet sich in Kombination mit den gleichstromgekoppelten Verstärkern besonders für die Untersuchung von Transistor-Schaltungen. Der Eingangs-Messkopf ist kompakt, leicht zu handhaben und belastet die zu untersuchende Schaltung nur mit 2 pF. Die z.B. in der Kernphysik auftretenden identischen Impulse mit willkürlichem Abstand können genau so gut dargestellt werden wie kurze Impulse geringer Frequenz, die besonders hell erscheinen. Weitgehende Transistor-Bestückung macht das Gerät kompakt und tragbar.

Modell L 362 entstand als Weiterentwicklung einer Konstruktion des Kernenergie-Forschungsinstitutes in Harwell und arbeitet nach dem Probenprinzip: die Elektronenstrahlspur entsteht als NF Gegenbild der Eingabe aus einer Reihe von Punkten, wobei jeder Punkt aufeinanderfolgenden Impulsen als Probe entnommen wird. Eine Speicherschaltung hält den Punkt fest, bis die folgende Probe entnommen ist. Dadurch ist der Elektronenstrahl in den meisten Fällen für über 80% der Periodenzeit „an", und es entsteht eine Spur grosser Helligkeit ohne Nachablenkungsbeschleunigung.

Betrieblich sind die Vergleichsschaltung, sowie die X und Y Speicherkreise das Herz des Gerätes. Der Ausgang der X Speicherschaltung wird mit einer Ablenkwellenform des schnellen Kippgenerators verglichen. Wenn die beiden übereinstimmen, gibt die Vergleichsschaltung einen Impuls ab, der das Nehmen einer Probe triggert. Gleichzeitig wird dem Speicherkreis ein Impuls zugeführt, der die gespeicherte Ladung reduziert. Der Triggerimpuls für die Probe tritt daher verhältnismässig früher auf, und der Kathodenstrahlpunkt bewegt sich für aufeinanderfolgende Wiederholungen nach links. Sowie die gespeicherte Ladung unter einen vorgewählten Pegel fällt, wird die Schaltung gelöscht und der Rücklauf beginnt.

Die zu untersuchende Eingabe wird einer Probenschaltung zugeführt, die in einen kleinen, getrennten Messkopf eingebaut ist. Die Eingangsspannung ladet den Eingangskondensator des Gerätes auf, und der Triggerimpuls für die Probe löst die Zuführung der Ladung über einen Verstärker zum Y Ladungsspeicher aus. Die gespeicherte Ladung ist daher proportional zur Eingangsspannung zur Zeit der Probennahme.

Ein zweiter Impuls wird vom X Kreis dem Y Ladungsspeicher zugeführt und dadurch eine der gespeicherten Ladung entsprechende Spannung über den Y Ablenkverstärker an die Y Platten der Bildröhre angelegt. Die X Ladungsspeicherschaltung gibt auch Impulse ab, die den Bildschirm verdunkeln, während sich der Punkt bewegt.

Eine zweite Triggerimpulseingabe kann der Triggerverzögerung und dann dem schnellen Kippgenerator zugeführt werden, der die Ablenkwellenform an die Vergleichsschaltung abgibt, muss aber der Signaleingabe um 0,05 bis 2 μs vorausgehen.

EE 15 761 *für weitere Einzelheiten*

NETZGERÄT FÜR BILDWANDLER

(Abbildung Seite 701)

Sionic Ltd, Cromwell House, 93 Wood End Green Road, Hayes, Middlesex

Das stabilisierte Netzgerät Type 359A wurde besonders für den Betrieb der Mullard Bildwandlerröhre entwickelt.

Die stromstabilisierte Versorgung der Fokussierungsspule liefert 200 ... 500 mA für eine Nennbelastung von 700Ω. Eine Belastungsänderung von ±100Ω ruft eine Stromabweichung von 1% hervor.

Der Hochspannungsteil liefert 5 ... 14,5 kV bei 1 μA mit einer 1 μA Anzapfung für das Gitter. Ohne Gitteranzapfung stehen 100 μA zur Verfügung. Der doppelte Spitzenwert der Restwelligkeit ist geringer als 1 V und die Gesamtstabilisierung besser als 2%.

EE 15 762 *für weitere Einzelheiten*

MINIATURSTECKER UND -SOCKEL

(Abbildung Seite 701)

Harwin Engineers Ltd, Rodney Road, Portsmouth, Hampshire

Der als Harwin W3000/3001 bezeichnete Kleinststecker und -sockel aus Nylon kann mit 4,76 mm Mittellinienabstand montiert werden. Die vergoldeten Kontakte sind für 7,5A bei 750 V berechnet, der Kontaktwiderstand ist durchschnittlich 2 mΩ und die Isolation besser als 10^6Ω. Arbeitstemperaturen bis zu 100° sind zulässig, und der Widerstand gegen Stoss und Schwingungen soll ausgezeichnet sein.

EE 15 763 *für weitere Einzelheiten*

EINREIHEN-ZIFFERNSKALEN

(Abbildung Seite 701)

Amphenol (Great Britain) Ltd, Ormond House, 26/27 Boswell Street, London, W.C.1

Es ist bekannt, dass das zwangsläufig schnelle Ablesen und Einstellen von Skalen der Grund für Ablesefehler ist, und es wurde festgestellt, dass die einreihige Zifferndarstellung die grösste Genauigkeit ergibt unter Bedingungen, in denen schnelles Ablesen und Einstellen erforderlich sind.

Diese Tatsachen führten zur Entwicklung der Kleinskalen der Borg 1300-Reihe. Um durch einreihige Zifferndarstellung den grössten Vorteil zu erreichen, werden die Ziffern in direktem Kontrast zu ihrem Hintergrund angefertigt, d.h. weiss auf schwarz oder schwarz auf weiss. Ein grosses, aus einem Stück bestehendes, gewölbtes und abgedichtetes Schutzglas ermöglicht Weitwinkelbeobachtung. Um Höchstempfindlichkeit und -genauigkeit zu erzielen, ist der Bedienungsgriff direkt auf die einzustellende Spindel montiert, sodass toter Gang, der durch eine Getriebeübersetzung auftreten könnte, vermieden wird.

Modelle können mit „Fingerspitzen"-Bremsen geliefert werden, die die Einstellung bei Stop und Vibration festhalten. Folgende Typen sind lieferbar:

Modell 1307. Dreistellige Skalen, die in zehn Umdrehungen des Bedienungsknopfes von 0-999 zählen. Mit „Fingerspitzen"-Bremse.

Modell 1308 wie oben, aber ohne Bremse.

Modell 1304. Vierstellige Skalen, die bei 100 Umdrehungen von 0-9999 zählen.

Modell 1305. Fünfstellige Skalen, die bis 1000 Umdrehungen von 0-99999 zählen.

EE 15 764 *für weitere Einzelheiten*

UKW-MESSENDER

(Abbildung Seite 701)

Airmec Ltd, High Wycombe, Buckinghamshire

Airmec Ltd hat vor kurzem die Erweiterung des Fertigungsprogramms durch den neuen UKW-Messender Type 204 angekündigt.

Das Gerät bestreicht das Frequenzband von 1...320 MHz in fünf Bereichen. Die Betriebsfrequenz wird auf einer beleuchteten Filmskala angezeigt, die für jeden Bereich 1,22 m lang ist. Die Eichgenauigkeit wird durch einen eingebauten Quarz-Kontrolloszillator gewährleistet.

Die Stabilisierung des Ausgangspegels auf jeden gewünschten Wert von 2 μV... 220 mV ist eine bemerkenswerte Eigenschaft, die das ermüdende Prüfen und Wiedereinstellen des Ausgangs bei Benutzung verschiedener Frequenzen vermeidet.

Ein eingebauter 1 kHz Oszillator kann für Amplituden- und Frequenzmodulation Verwendung finden. Ein eingebautes Messgerät überwacht den Modulationsgrad bis 50% und Frequenzhub bis 80 kHz mit einer Genauigkeit von 5%. Fremdmodulation von 30 Hz ... 15 kHz kann entweder getrennt oder gleichzeitig mit der eingebauten Modulation angelegt werden. Ebenso kann Impulsfremdmodulation mit Taktfrequenzen von 30 Hz ... 50 kHz benutzt werden.

Ein 52Ω Stufendämpfungsglied konstanter Impedanz ist eingebaut, und ein Anpassungskabel für die Umwandlung der Quellenimpedanz zu 75Ω wird mitgeliefert.

EE 15 765 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Access—ein ruhendes Schaltsystem mit Kaltkathodenröhren von R. W. Brierley

Zusammenfassung des Beitrages auf Seite 646-654

Die neuen, grossen Fortschritte in der Automatisierung der Fertigung haben zu sehr komplexen Steuersystemen geführt. Der grösste Teil der Anlagen benutzt die „Ein-Aus" Methode und verwendet Relais als logische Elemente. Es wird schwierig, den hohen Betriebsleistungsstandard einer solchen Anlage aufrecht zu erhalten, wenn sie zu komplex wird. Ein zuverlässiger Ersatz für die elektromechanischen Relais wurde daher gesucht, und einige Systeme mit ruhenden Elementen sind bekannt geworden. Ein System, das Kaltkathodenröhren benutzt (ACCESS-Austin Cold-Cathode Electronic switching System), wird beschrieben.

Ein „Vektorgraph" von K. G. Freeman

Zusammenfassung des Beitrages auf Seite 655-658

Der beschriebene Vektorgraph gibt eine vektorielle Darstellung eines Chrominanzsignals des NTSC-Types. In dem hochempfindlichen Gerät sind auch eine Anzahl anderer Eigenschaften, einschliesslich laufende Prüfung der Verstärkung und Quadraturregelung, vorgesehen. Das Gerät ermöglicht schnelle Einschäzung der Phasen- und Amplitudencharakteristiken des Chrominanzsignals, die für den direkten Demodulationsvorgang des Signal-Strahlerzeugungssystems der Farbbildröhre von besonderer Bedeutung sind.

Halbleitende Verbindungen von D. A. Wright

Zusammenfassung des Beitrages auf Seite 659-665

Zuerst werden in diesem Beitrag die wichtigeren Parameter besprochen, die das Verhalten von Halbleitern bestimmen. Diese Uberlegungen werden dann zur Beurteilung der verschiedenen chemischen Verbindungen herangezogen, die bisher untersucht wurden; mittlere Parameter werden angegeben. Unter Berücksichtigung dieser Werte wird die Nutzbarkeit der Materialien für verschiedene Anwendungen diskutiert. Für jeden Verbindungstyp werden bestimmte Tendenzen für die Beziehungen zwischen den Halbleiterparametern und den physikalischen Eigenschaften beobachtet. Diese Tendenzen werden beschrieben und ihre Ausdeutung aufgezeigt. Die für thermoelektrische Anwendungen wichtigen Parameter werden zusammen mit dem Einfluss der ersten Diskussion auf die Materialauswahl kurz besprochen.

Stehwellenverhältnis mit automatischer Anzeige von M. Kollanyi und R. M. Verran

Der übliche Stehwellenverhältnis-Anzeiger mit seinen zeitraubenden Einstellungen kann durch einen automatischen Anzeiger ersetzt werden, der mittels eines Mess– oder Ziffernsichtgerätes direktes Ablesen ermöglicht. Die Schaltung kann für jeden Hohlleiter mit Schlitz oder äquivalente Einrichtungen Verwendung finden. Nur eine einzige Bewegung des Messkopfschlittens ist notwendig, um das korrekte Stehwellenverhältnis abzulesen.

Zusammenfassung des Beitrages auf Seite 666-671

Das beschriebene System stützt sich auf einen Maximum-Minimum-Detektor, der die während der Abtastperiode auftretenden Grenzwerte der Spannungen entdeckt und speichert. Das Verhältnis dieser Spannungen kann mittels verschiedener elektronischer Methoden, die auch beschrieben sind, berechnet werden.

Ein Reststehwellenverhältnis unter 1,5 kann mit einem Höchstbereich von 1 : 3 für Stehwellenverhältnis-Messungen erreicht werden. Falls es gewünscht wird, kann dieser Bereich noch erweitert werden; diese Erweiterung hängt jedoch von den angewandten Methoden ab.

Gasgefüllte Röhren als Musikgeneratoren von Alan Douglas

Zusammenfassung des Beitrages auf Seite 672-673

Die offensichtlichen Vorteile gasgefüllter Zweielektrodenröhren für Kippgeneratoren sollten andeuten, dass viele Aufgaben der Erzeugung elektrischer Musik dadurch gelöst werden könnten; keines der käuflichen Geräte benutzt jedoch solche Bauelemente. Einige neue Schaltungen machen trotz der ihnen eigenen physikalischen Begrenzungen von diesen preisgünstigen gasgefüllten Röhren den bestmöglichsten Gebrauch.

Flächentransistoren in einem Dreieckmodulationssystem von B. E. Williams

Zusammenfassung des Beitrages auf Seite 674-680

Ein mit 14kHz Taktfrequenz arbeitendes Dreieckmodulationssystem wird beschrieben, das Einfachsprechverbindungen mit guter Verständlichkeit ermöglicht. Die einzige Handbedienung des Gerätes erfolgt durch den Sprechknopf; alle anderen Einstellungen werden entweder vorher gemacht oder automatisch betätigt. Der Empfänger regeneriert die ankommenden Signale durch Spannungs– und Zeitunterteilung, bevor sie zum Entschlüssler gespeist werden. Das Gerät arbeitet zufriedenstellend über einen sehr weiten Bereich von Umgebungstemperaturen und ist für Einsatz mit ausgeglichenen Fernsprechleitungen oder Funkbrücken geeignet. Eine Stromquelle für 6 . . . . 12V ist erforderlich.

Ein kleines, stabilisiertes Hochspannungs-Netzgerät mit variablem Ausgang von J. D. O'Toole

Zusammenfassung des Beitrages auf Seite 681-683

Ein wachsendes Anwendungsgebiet besteht für stabilisierte Hochspannungs-Netzgeräte, für die keine hohe Leistung erforderlich ist. Durch die scheinbaren Beschränkungen lieferbarer kleiner Röhren wurde der Bedarf für dieses Gebiet nicht genügend befriedigt. Eine Grundschaltung wird beschrieben, die diese scheinbaren Beschränkungen überwindet. Eine typische Schaltung dieser Art wird behandelt und Leistungswerte werden angegeben.

Anordnung für die Abgabe einer genauen Vektorspannung von D. J. Collins und J. E. Smith

Zusammenfassung des Beitrages auf Seite 684-685

Für viele elektronische Anwendungsgebiete werden Spannungen benötigt, deren Phase und Amplitude gegenüber einem Bezugspegel bekannt sind. Ihre Genauigkeit hängt hauptsächlich von der Genauigkeit der Bauelemente und des Phasenschifters ab, wenn man von elektro-mechanischen Vorrichtungen absieht. Der Beitrag beschäftigt sich mit einer möglichen Anordnung, die eine genaue Vektorspannung abgeben kann, solange ihre Amplitude geringer als der Bezugspegel ist und mit ihr in einem Phasenverhältnis von 0° bis 360° steht. Eine derartige Anordnung ist für die Eichung von Phasenschiftern und Phasenmessgeräten sehr wertvoll.

Eine alternative Vergleichsmethode für elektrische Eigenschaften von Epoxy-Giessharzen von D. H. Thompson

Zusammenfassung des Beitrages auf Seite 686-687

Die Beitrag beschreibt ein Verfahren zur Feststellung der Dielektrizitätskonstante, Verluste und des spezifischen Widerstandes von Epoxy-Giessharzen über einen grossen Temperaturbereich und für Frequenzen bis zu 5 MHz.

Gegenüber der üblichen Methode von Hartshorn and Ward muss eine geringere absolute Genauigkeit in Kauf genommen werden; jedoch verdient diese Methode ausgedehntere Anwendung, wo es sich in der Hauptsache um den Vergleich von Giessharzen und der Temperaturbeständigkeit ihrer elektrischen Parameter handelt.

Besonders können absolute Werte nach dieser Methode angegeben werden, vorausgesetzt, dass die Resultate bei Labortemperatur nachgeprüft und normalisiert werden.

Ein transistorisierter Niederspannungsregler von J. H. Deichen

Zusammenfassung des Beitrages auf Seite 688-689

Die zur Speisung von Röhrenheizfäden mit stabilisiertem Gleichstrom zur Verfügung stehenden Schaltungen werden untersucht und ihre Begrenzungen besprochen. Eine einfache Schaltung, die einen Transistor und zwei Zenerdioden verwendet, wird mit Entwurfsunterlagen und Leistung beschrieben.

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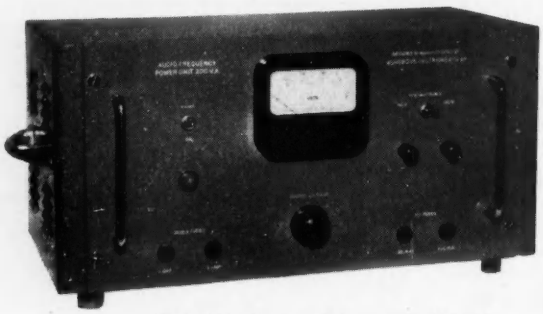

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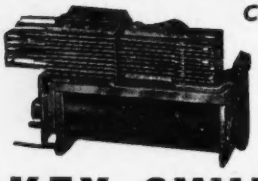

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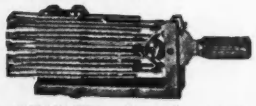

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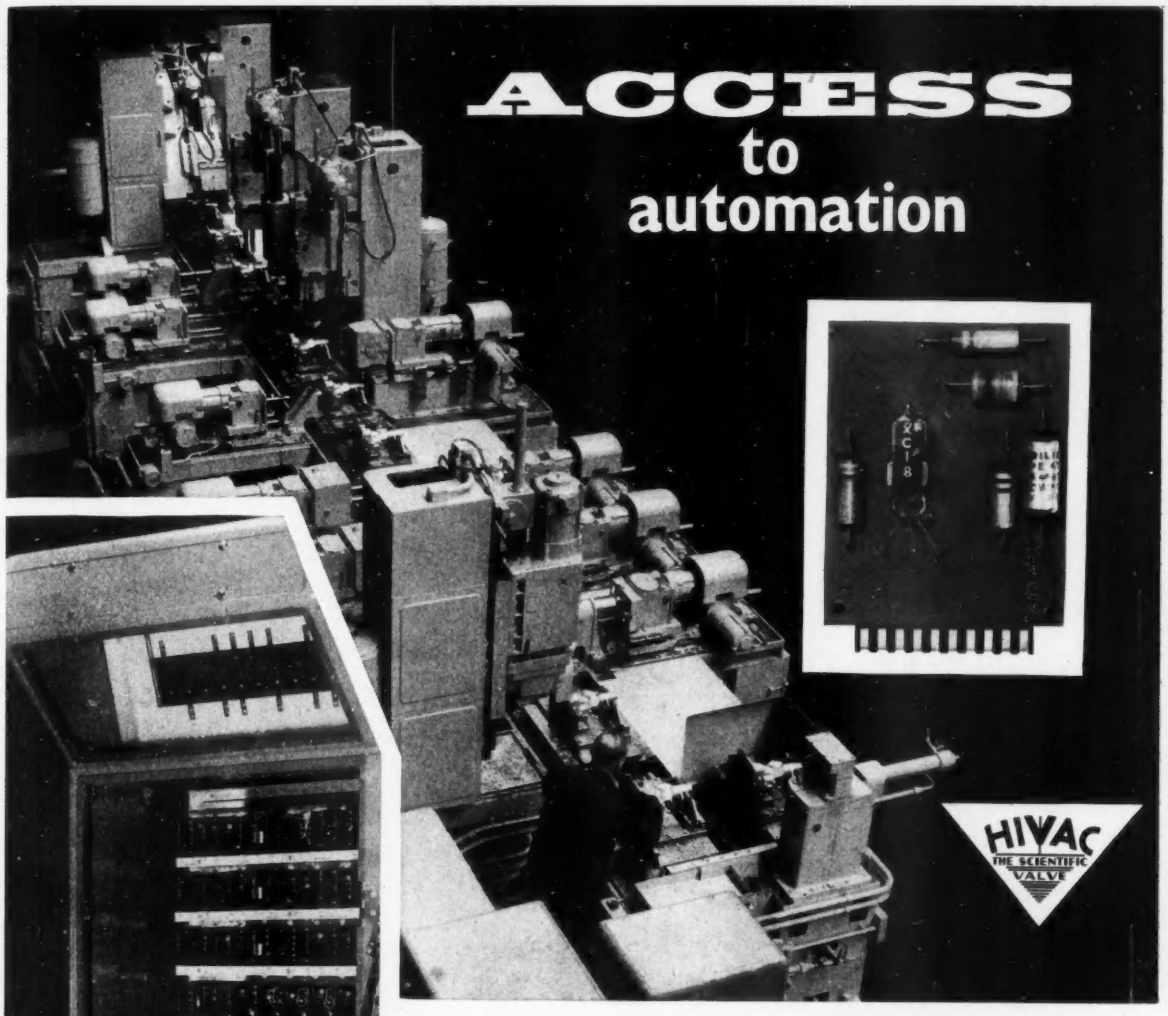

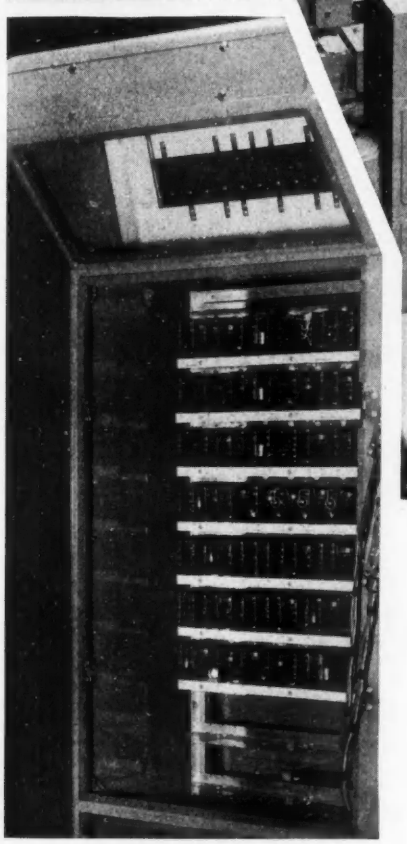

The Access Cold Cathode Tube Control Panel

(*Inset above*) **A Typical Plug-in Logical Circuit Element**

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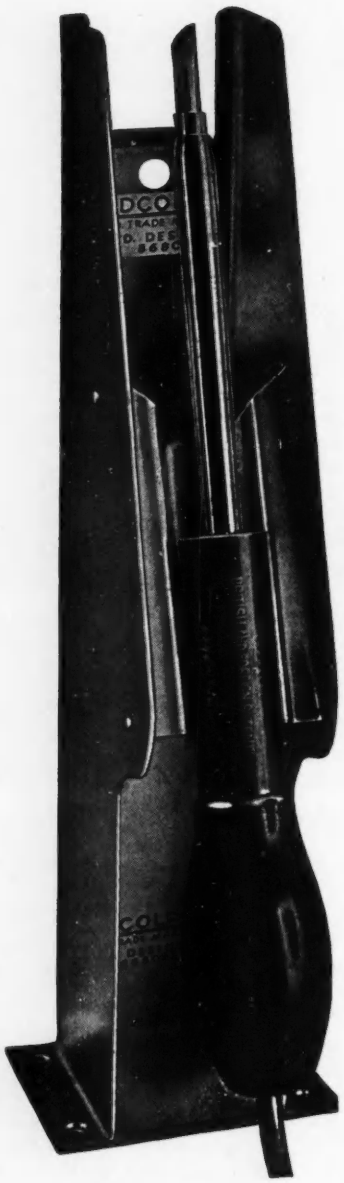

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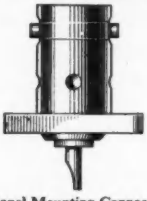

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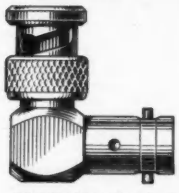

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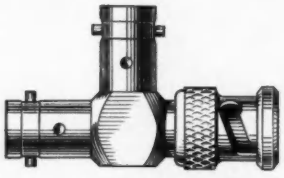
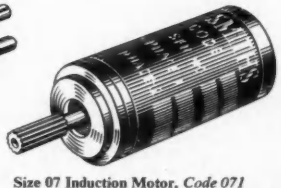


BNC Tee Adaptor LF22 *Weight ·85 oz. (24.0 grm.)*

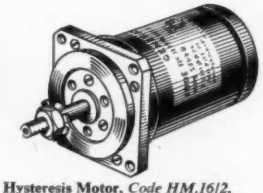
Smiths BNC Connectors are manufactured and finished to very high standards. They are small, lightweight, weatherproof and quick to connect and disconnect. Several of the items in the range, used on Service equipment, have already been granted Quality Approval by R.C.S.C., and also Departmental Approval by S.R.D.E. All connectors are interchangeable with equivalent U.S. military types based on U.S. specification MIL-C-3608. Single-hand operation facilitates their use in awkward locations, and their positive locking action ensures vibration-proof connection at all times. Insulation throughout the entire range is P.T.F.E. Finish is silver-plate. Max. current, 1 ampere; max. voltage, 500V peak; nominal impedance, 50 ohms. The range includes 'Straight-through', 'Right-angle', and 'Tee' connectors, with cable, panel and bulkhead mountings. Sealed items are pressure tested to 25 p.s.i., or higher if required.

SMALL A.C. MOTORS, SYNCHROS & GENERATORS

Size 11 Torque Receiver, *(low voltage). Code ACS 1/AL, 400 c.p.s.; rotor/stator voltage 26/11.8; D.C. resistance 5.4 ohms; Weight 2.8 oz.*



Size 07 Induction Motor, *Code 071 SCM/1. 2-phase 400c.p.s. Centre-tapped control and reference phase windings. Stall torque 8 gm. cm.; No load speed 9,000 r.p.m. Weight 1.25 oz.*



Hysteresis Motor, *Code HM.16/2, 3-phase 400 c.p.s.; Supply voltage 115 V; Synchronous torque 270 gm. cm. at speed of 12,000 r.p.m.; Weight 27.25 oz.*

SYNCHROS: A very wide choice of synchros is offered. The Size 11 torque receiver—illustrated here—is just one of over twenty different synchro types in Smiths' range. All are listed in Smiths 'Components' catalogue, which gives full installation, electrical and mechanical data for each type. In addition, an entirely new range (BCS) of high-temperature, Grade 1 synchros will shortly be available.

SMALL A.C. MOTORS: The wide range produced by Smiths falls into three main types: Hysteresis motors, Drag-cup motors and Induction motors. The Size 07 Induction motor, illustrated here, is the smallest unit of its kind in production in this country.

Smiths small motors, synchros and generators are now offered at very competitive prices, particularly for quantity orders. They are noted for their high quality and technical performance. Easy and permanent type identification is ensured by the special system of labelling used.

SPECIAL TECHNICAL ADVISORY SERVICE

Smiths have gained extensive experience and technical knowledge in the production and practical application of small components and connectors. This can prove invaluable to engineers engaged in the development of new electronic equipment. Our experts will gladly advise or assist on any problem that may arise in applying the range of units offered, and an efficient design and development service with close technical liaison is available to design engineers.

PLEASE WRITE FOR FURTHER INFORMATION

Special descriptive literature covering Smiths Components and BNC Connector ranges will be sent on request. When writing, please state which range interests you, giving the name of your company and the position you occupy.

SMITHS AVIATION DIVISION

SMITHS AVIATION DIVISION, KELVIN HOUSE, WEMBLEY PARK DRIVE, WEMBLEY, MIDDX. Tel: WEMbley 8888 Grams: Airspeed, Wembley. Telex: 25366

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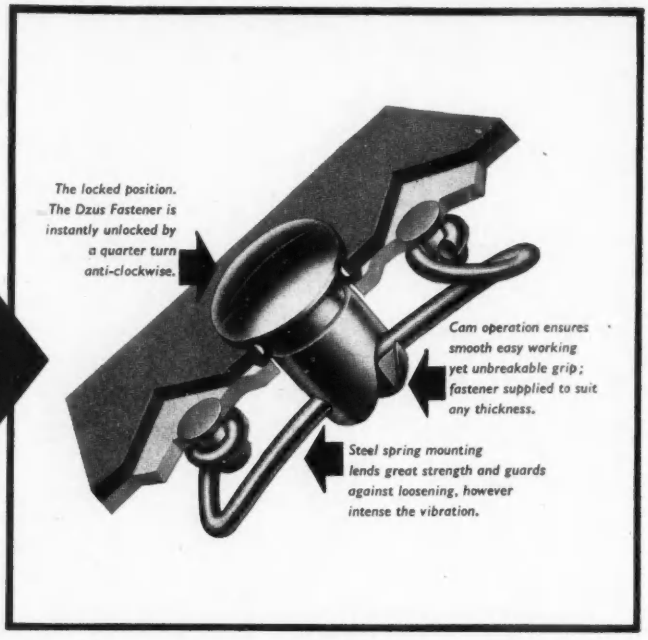
The fastest fastener...

THE MOST RELIABLE... YET SIMPLE

● Dzus can easily be fitted in solid or laminated materials, regardless of thickness. Dzus have tremendous holding power. Quick in action! Vibration proof! They are indispensable for hinged or removable parts which need frequent inspection, cleaning or adjustment. THE FASTEST FASTENER with the 101 uses for Inspection Hatches and Panels, Engine Covers, Machinery Guards, Fascia Panels, Radiator Grilles and with a variety of uses in the Electronic, Motor Vehicle and Shipbuilding Industries.


The locked position. The Dzus Fastener is instantly unlocked by a quarter turn anti-clockwise.
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TYPES RV and RW

TYPE RV
has a useful frequency range from D.C. to over 400Mc/s.
Eleven positions, each spaced 30°.
Maximum attenuation 10dB per step.

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has a useful frequency range from D.C. to over 900Mc/s.
Six positions, each spaced 60°.
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★ Choice of terminations includes types 83, N. P.E.T., Pattern 2, etc.

★ Choice of output impedance. 50, 75, 100 ohms.

★★ **Send for illustrated leaflet showing how to incorporate these new attenuators in YOUR equipment.**

Type RV assembly, illustrated here, is one of the many now being incorporated into Services and industrial equipment.

Hatfield Instruments Ltd. Crawley Rd., Horsham, Sussex. *Tel.: Horsham 3232*

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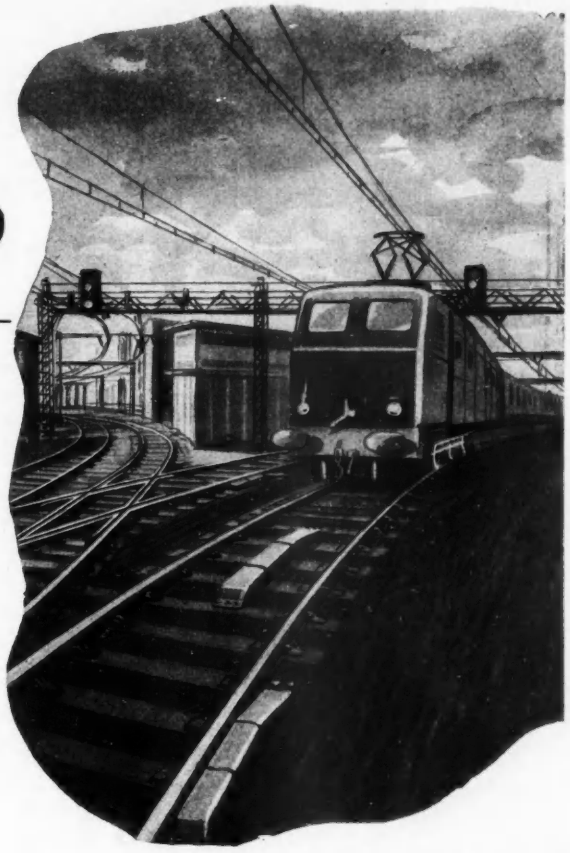
P.M.A. Leadership



The large magnet on the track operates a receiver magnet in the train, and safety is thereby ensured.

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Almost every technical advance brings with it requirements for yet more PMA permanent magnets: radar, television, automatic train control, factory automation and nuclear power stations are but examples.

PMA members collaborate in the design, taking full advantage of the ever-greater range of materials developed by the PMA Central Research Laboratories.

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Pioneers and Leaders in Permanent Magnet Materials

SHEFFIELD

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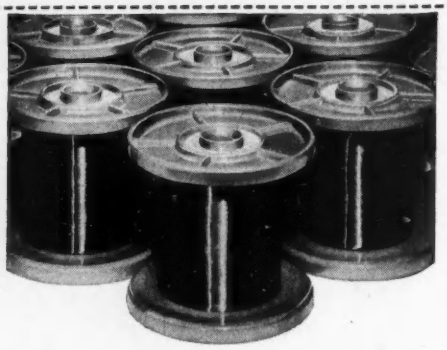
LEWCOS

Supplied with standard coverings of cotton, silk, rayon, enamel, LEWMEX (synthetic enamel), glass and asbestos.

Insulated resistance wires



for resistors in instruments, radio, television, electronic and control apparatus and many other applications.

★ *Available over a range of sizes in VACROM (nickel-chrome) 80/20 or 15% and EUREKA (cupro-nickel). All conform to BSS 115/1954.*

A technical information and advisory service is offered.

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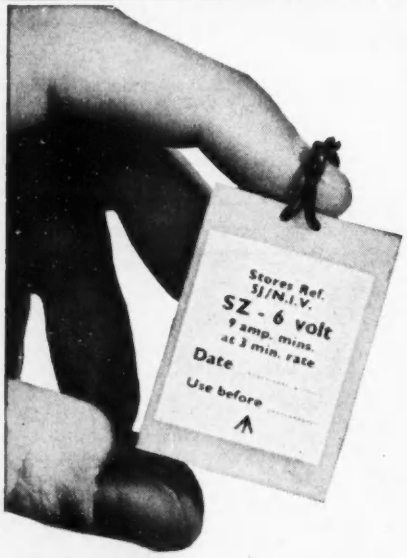

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Venner Type SZ.6
is 1 3/16" long, 1 1/16" broad and 1 3/4" high.
Capacity: 9 amp. minutes at 3 minute rate.

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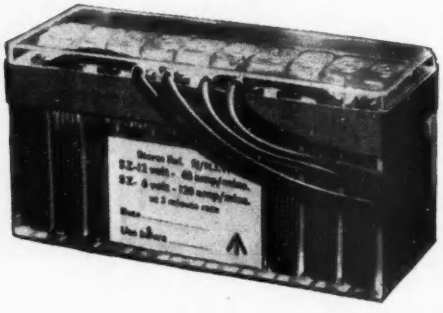
is 4 13/16" long, 1 13/16" broad and 2 3/8" high.
Capacity: 60 amp. minutes—12V. at 3 minute rate or 120 amp. minutes—6V. at 3 minute rate.



VENNER Accumulators

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A member of the Venner Group of Companies

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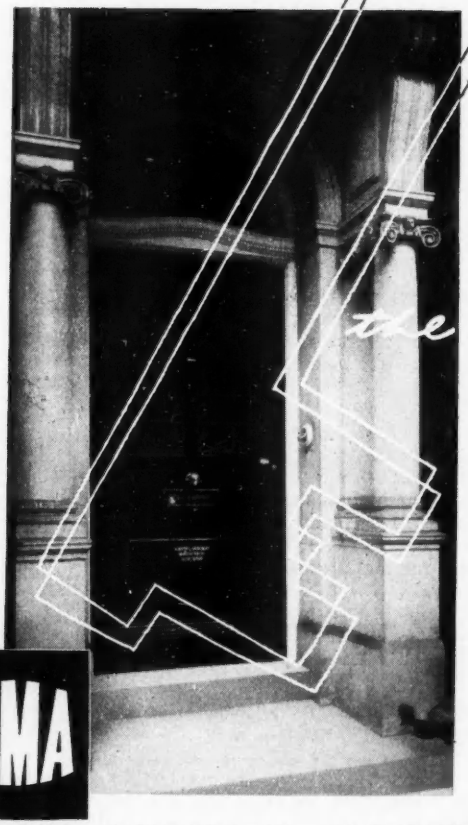

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AUSTIN COLD CATHODE ELECTRONIC SWITCHING SYSTEM

& DONOVAN

Patented by
THE AUSTIN MOTOR CO., LTD.

The NEW Access System of Control described on page 646 of this issue offers a great number of advantages when applied to many types of complex machine tool and conveyor installations.

The Donovan Electrical Co. Ltd., are pleased to announce that they have been licensed by the Austin Motor Co. Ltd., to supply and manufacture equipment employing this advanced system.

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Stechford 2277 (5 lines)

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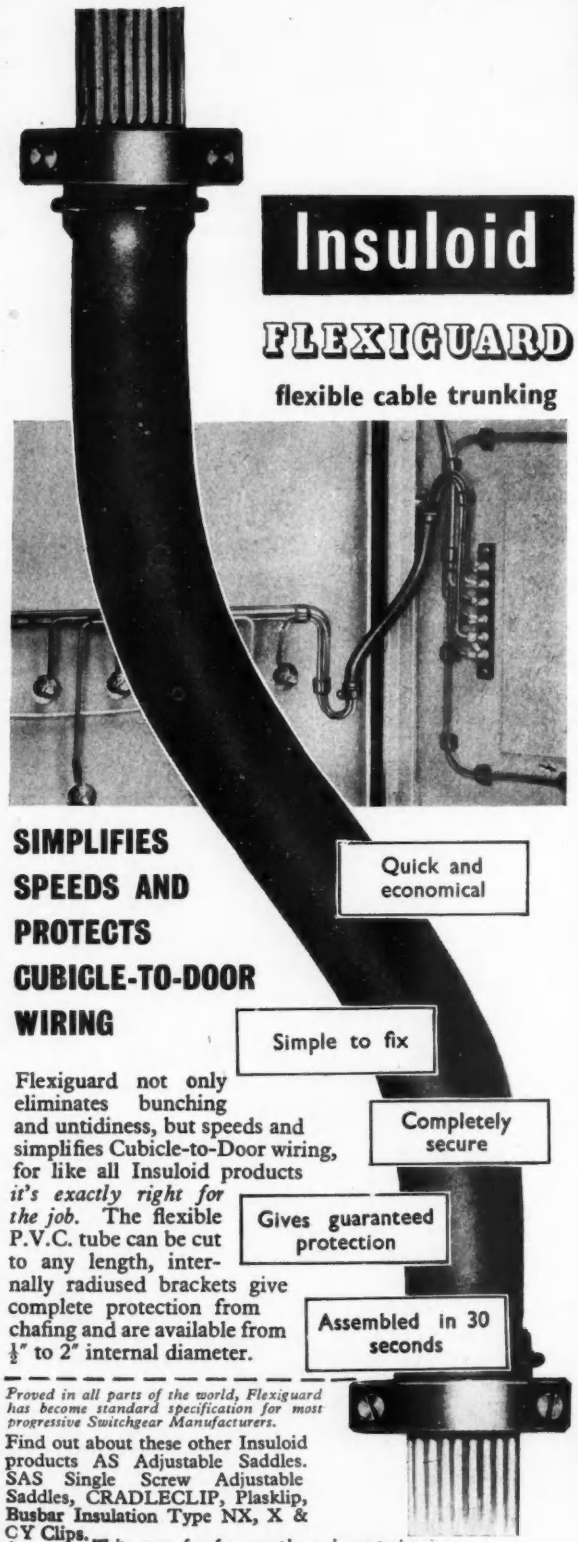

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Assembled in 30 seconds

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Proved in all parts of the world, Flexiguard has become standard specification for most progressive Switchgear Manufacturers.

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Products of BRITISH DRIVER-HARRIS

No. 3 Superfine Wires

Manufacturers of precision resistors and potentiometers demand resistance wires so fine that they can hardly be seen. Some ask for wire with a high specific resistance. Others require a comparatively low specific resistance but it must remain constant with changing temperatures. Yet others call for wire with both a high and an unchanging resistance.

Wires are required in various tempers and finishes, for example, hard-drawn, annealed, bright, oxidised, enamelled, enamelled and silk-covered—there's no end to the variations needed for different jobs. Fortunately, there's no end either to our ability to meet them.

Superfine wires are produced from ·002 in. (0·05 mm.) downwards in alloys which are famous, Nichrome*, Nichrome* V, Karma* and Advance*. Alloys which offer all the necessary resistance properties. Finishes which meet all requirements. It's not surprising, perhaps, that our reputation in the superfine wire field is unique.

Nichrome* & Nichrome* V Nichrome* (65/15 type nickel-chromium-iron) and Nichrome* V (80/20 type nickel-chromium) are the alloys most suitable where a high resistance is necessary and where the change in resistance due to temperature does not hinder satisfactory performance.

Karma* This is essentially a modified 80/20 nickel-chromium alloy, developed especially for the electronics industry, which combines a high specific resistance with a low temperature coefficient.

Advance* Wires of this 60/40 copper-nickel alloy have a low temperature coefficient and a fairly high specific resistance—important properties in precision resistors which must have constant resistance over a wide temperature range.

For further information write for Data Sheet No. 1, a 4-page booklet containing comprehensive technical information.

*REGD. TRADE MARK

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Cheadle Heath, Stockport, Cheshire.

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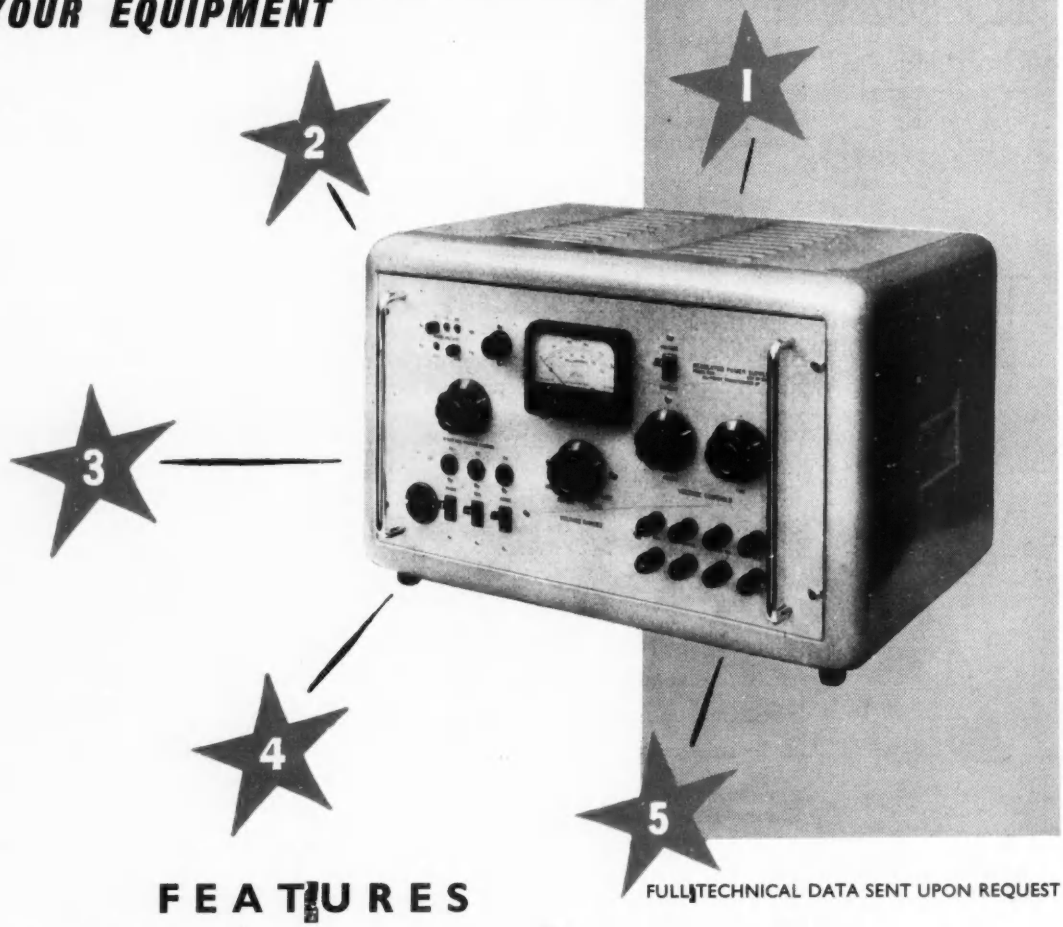
500 SERIES-
REGULATED POWER SUPPLIES

FOR STAR PERFORMANCE AND SUPERB STABILITY ON WHICH TO BASE YOUR EQUIPMENT



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FULL TECHNICAL DATA SENT UPON REQUEST

★ Price range from £70. ★ Stability up to ± .002%. ★ Thirteen models to choose from suitable for rack or bench mounting and complete with protective covers. ★ Voltage to 500 v and current to 500 mA. ★ Fine voltage control permits accurate setting.

If these units do not meet your requirements, designs are readily available for voltages to 20 KV or currents to 75 amps.

Also the makers of the well-known 'Lektrokit' the versatile chassis construction system.

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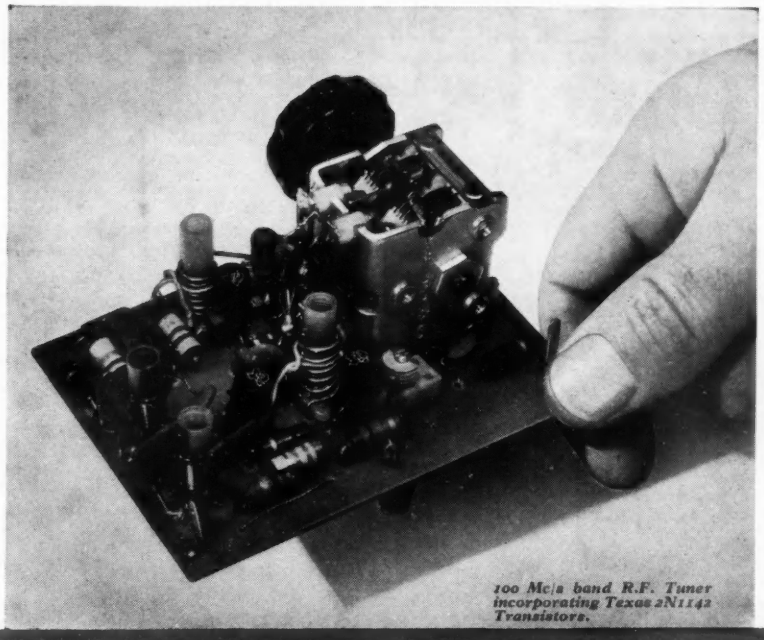
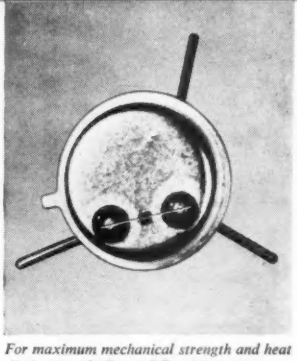


100 Mc/s band R.F. Tuner incorporating Texas 2N1142 Transistors.

NOW!
600 Mc/s TRANSISTORS
FROM TEXAS

Complete transistorization of highband v.h.f. and of much u.h.f. equipment is now a reality with the introduction of two new Texas Instruments diffused-base germanium transistors, the 2N1142 and the 2N1143.

With an alpha frequency cutoff of 600 Mc/s for the 2N1142 and 480 Mc/s for the 2N1143, and a total dissipation up to 750 mW at 25°C these transistors will have wide application in airborne communication and navigation equipment. For added reliability these diffused-base transistors are enclosed in the JEDEC-T05 welded case.



For maximum mechanical strength and heat dissipation, the Texas diffused-base construction mounts the wafer directly on to the header

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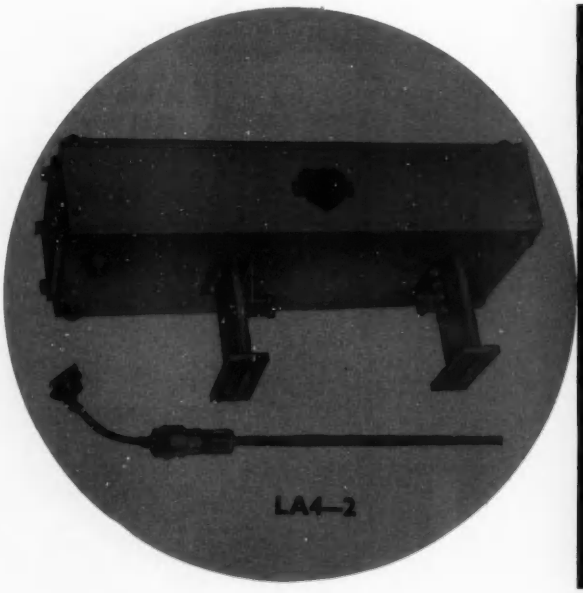
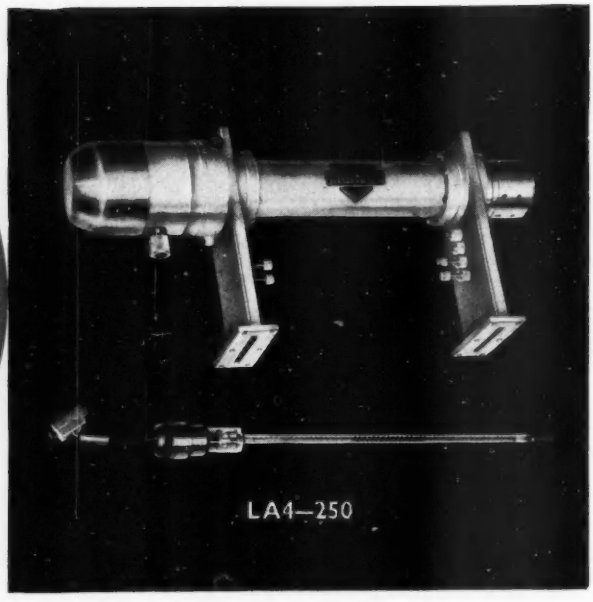
T 37

Forward wave amplifiers





	Tube Type No.	Mount Type No.	Description	Frequency Range (Gc/S)	Power Output (Sat.) (W)	TYPICAL OPERATION AS AMPLIFIER					
						Noise Factor (db)	Power Gain (db)	Attenuation at Ik=0 (db)	Helix Voltage (V)	Collector Voltage (V)	Collector Current (mA)
MICROWAVE LINK TUBES	LA4—2	P4L—1	Low noise tube	3.6 to 4.2	0.002	8.0	27	45	550	500	0.2
	LA4—250	P4L—2	High gain amplifier tube	3.6 to 4.2	0.2	24	31	50	1200	1250	3.5
	LB4—2	P4L—3	Power amplifier tube	3.6 to 4.2	2.5	29	31	60	1300	1250	25
	LB4—8	P4L—4	Power amplifier tube	3.8 to 4.2	8.0	30	37	60	1100	1150	50
	LA6—3	P6L—1	Low noise tube	5.9 to 7.6	0.003	8.0	28	45	600	550	0.3
	LA6—200	P6L—2	High gain amplifier tube	5.9 to 7.6	0.2	25	35	55	1350	1300	5.0
	LB6—12	P6L—3	Power amplifier tube	5.9 to 7.6	12	29	36	65	2400	1500	40
RADAR TUBES	LA9—3	P9L—1 / S9L—1 *	High gain broad band tube	7 to 11.5	0.006	23 / 18 *	27	40	1250	1350	0.55
	LA16—2	P16L—1 / S16L—1 *	High gain broad band tube	11.5 to 18	0.003	26 / 20 *	22	40	1600	1700	0.35

* Solenoid focusing system

EE 15 140 *for further details*

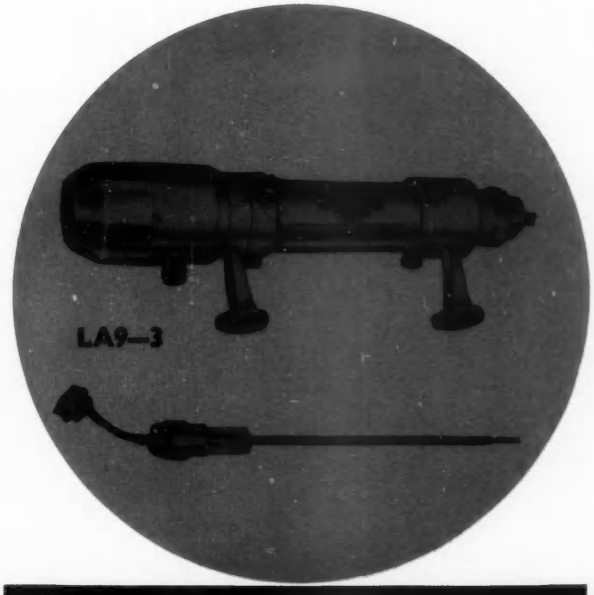
with focusing systems

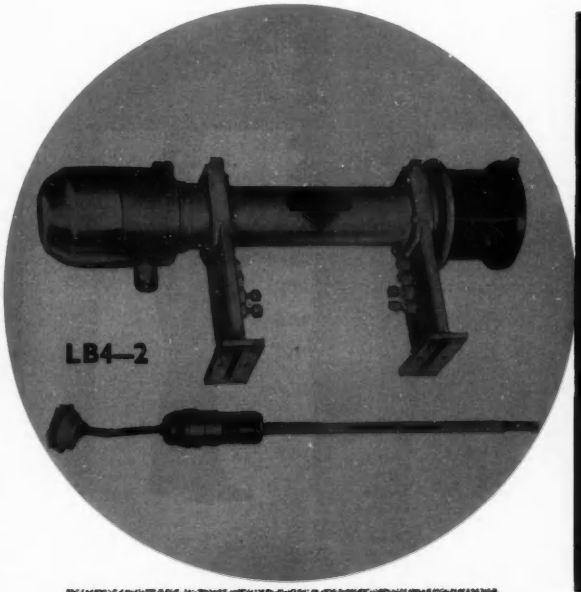
The Mullard range of forward wave amplifier tubes now comprises nine types for microwave link and radar applications.

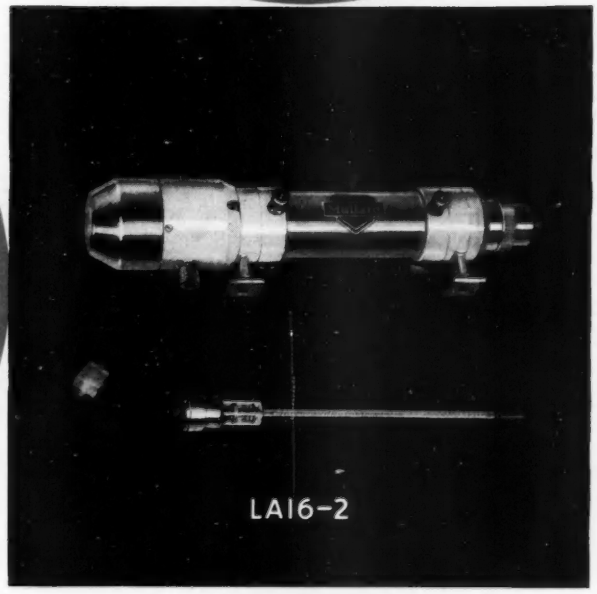
All tubes in the range are normally supplied with permanent magnet focusing systems and waveguide outputs, but solenoid systems are available on request. The permanent magnet systems eliminate the need for additional power supplies and cooling which is associated with solenoid focusing systems. They are comparatively small and light, and their simplicity makes a significant contribution to equipment reliability and economy.

The focusing systems are designed for easy installation and alignment of the tubes, and are fitted with adjustable matching screws.

Full details of Mullard travelling wave tubes, their focusing systems and other microwave valves are available from the address below.







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GOVERNMENT AND INDUSTRIAL VALVE DIVISION

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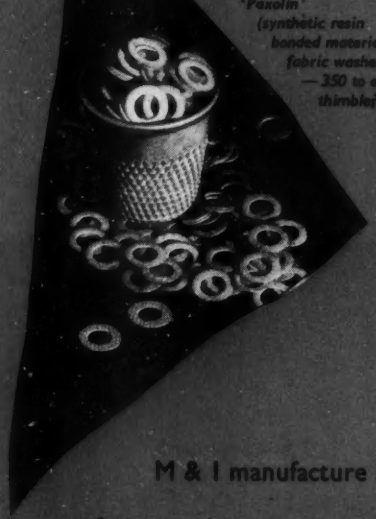
MVT371

We go from one extreme to the other



'Paxolin' (synthetic resin bonded material) fabric washers — 350 to a thimbleful.

A 400 kV outdoor re-entrant type transformer bushing.

M & I manufacture a wide range of electrical insulating materials suitable for the smallest component . . . and equipment for the largest installations and highest voltages.

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'PAXOLIN' is a registered trade name of The Micanite & Insulators Co., Ltd.

EE 15 142 *for further details*

Plessey

HYPERLYTICS*
give

ten years service

Long shelf life and a working life of 10 years are achieved in the new type of electrolytic capacitor developed by Plessey.

The exacting specifications demanded for specialised electronic equipment have been met by using a high purity etched foil material, and combining the direct Plessey process control with unique manufacturing methods.

With low leakage and high insulation characteristics, Hyperlytics can be supplied in a wide range of values between 0.5 and 12,000 μF. Two types are available, the 1000 series with a temperature range of —30°C to +85°C, and the 11,000 series with a range of —20°C to +50°C.

Capacitance tolerance for both types is normally —20 to +50% but closer limits can be achieved to meet special requirements.

Write for further details of these outstanding new components.

* *High Performance Electrolytic Capacitors*

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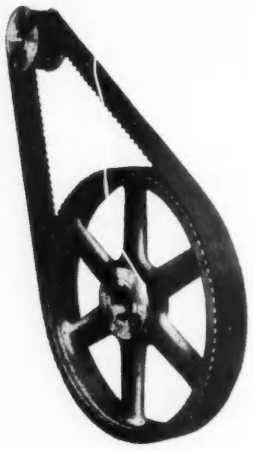
POWERGRIP

TIMING BELT DRIVES

AVAILABLE EX-STOCK FROM CROFTS



The belt drive with teeth.

- No slip, no power loss
- Accurate timing of synchronised drives.
- No maintenance, no tensioning devices, no lubrication.
- Almost 100% mechanical efficiency.
- Simple to install using Crofts Patent Taper Flushbushes.

PowerGrip drives up to 64 h.p. supplied from stock, up to 1000 h.p. available to order.

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THERMOCOUPLE TEST SET

CAT. No. 7556

Pye Instruments

The Thermocouple Test Set is compact, robust and fully portable: it is convenient in operation and a wonderful time-saver. Three instruments are combined as one to provide all the facilities required for testing thermocouples and their associated indicators, controllers, recorders and alarm relays. These comprise a potentiometer, a Wheatstone bridge and a potential source, which may all be used separately if required. The circuit and switchgear are so designed as to provide the most convenient test routine. A reversing polarity switch and thermometer are built into the set.

The Thermocouple Test Set is intended primarily for:

- ★ *Check of thermocouple calibration against standard thermocouples, etc.*
- ★ *Measurement of thermocouples and lead resistances: the reversing switch enables correction to be made for any inherent e.m.f. in the thermocouple.*
- ★ *Calibration of indicators, recorders and controllers under correct conditions of external circuit resistance.*

POTENTIOMETER: There are two ranges × 1, × 5. On the × 1 range. 0-20 mV reading down to 0.01 mV on the slidewire dial. On the × 5 range 0-100 mV reading down to 0.05 mV on the slidewire dial; standard cell, battery and galvanometer are incorporated. Accuracy ±0.1%.

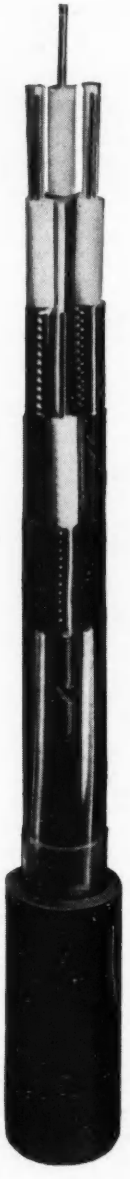
WHEATSTONE BRIDGE: Three dials, 4 steps of 10 ohms, 10 steps of 1 ohm and 10 steps of 0.1 ohm, form the series arm of the Wheatstone bridge and the accuracy of any setting is ±0.01 ohm.

POTENTIAL SOURCE: Comprises a battery and coarse and fine control, together with a main selector switch for 20, 50 and 100 millivolts.

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD., Granta Works, Cambridge, England
Tel: Cambridge 54411 (5 lines) *Grams: Pye, Cambridge*

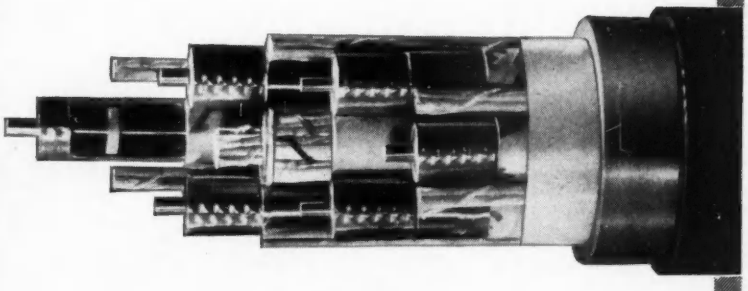
EE 15 144 *for further details*



4-core Type 163 Coaxial Cable

3-core Type 975 Coaxial Cable

S.T.C. COAXIAL CABLES FOR TELECOMMUNICATIONS



6-core Type 375 Coaxial Cable

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Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

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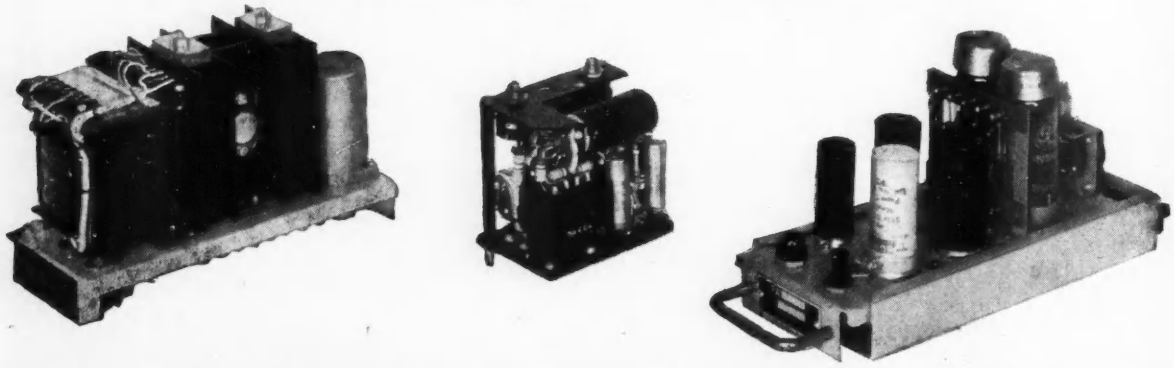

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Send for Publication EO.301 which gives full details.

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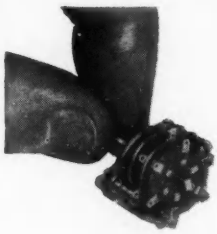

miniature

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by

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ARDENTE ACOUSTIC LABORATORIES LTD

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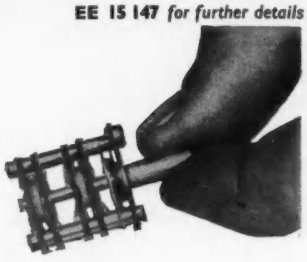
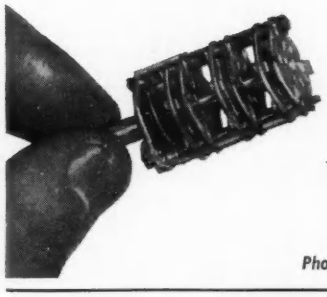
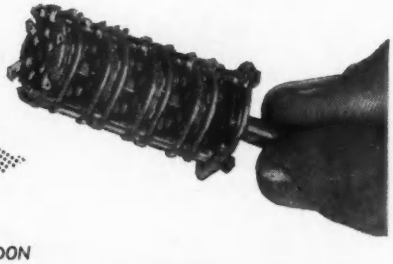


★ *full technical data upon request*





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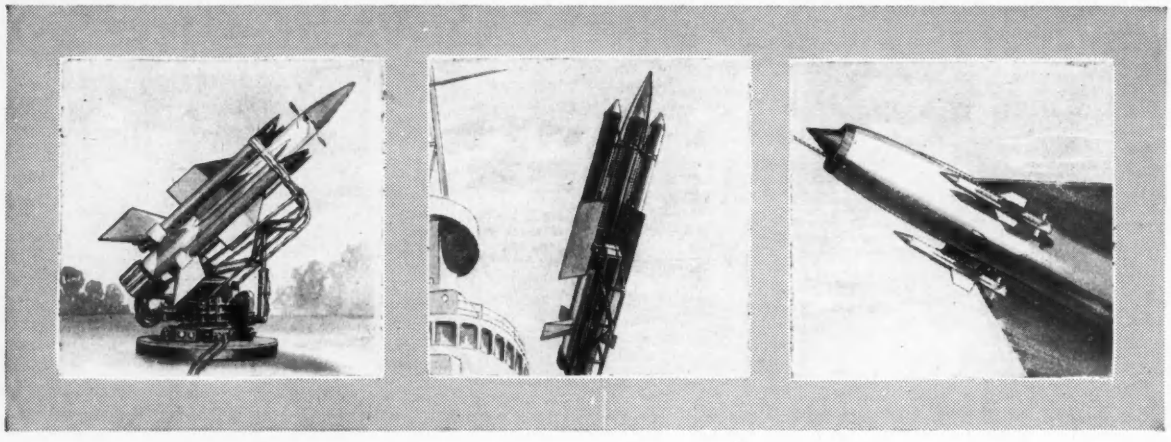

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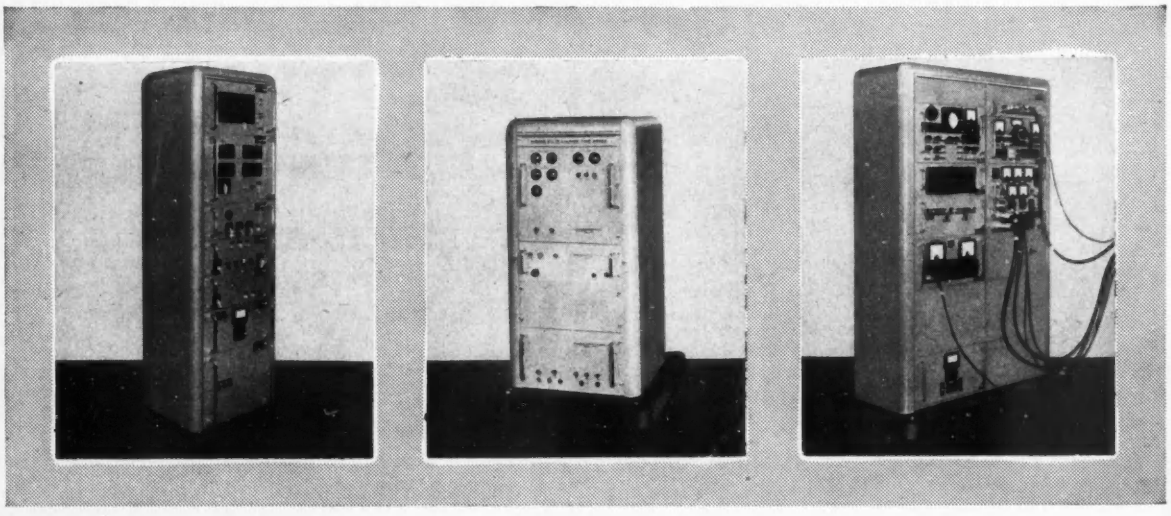

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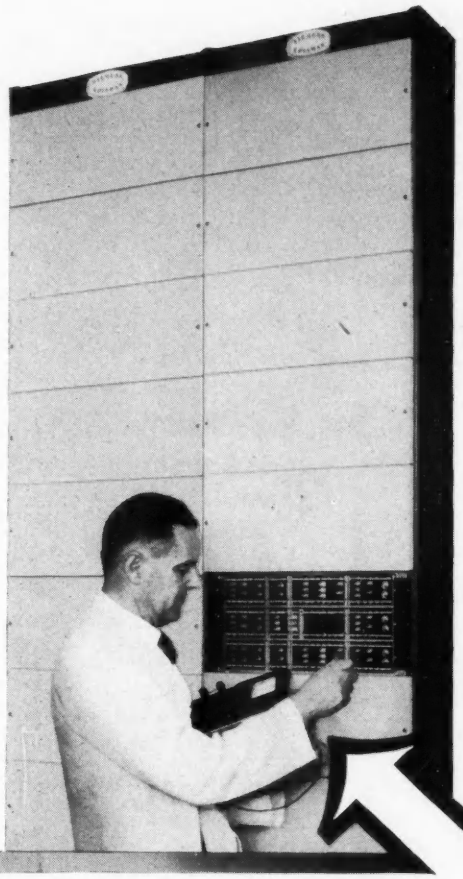
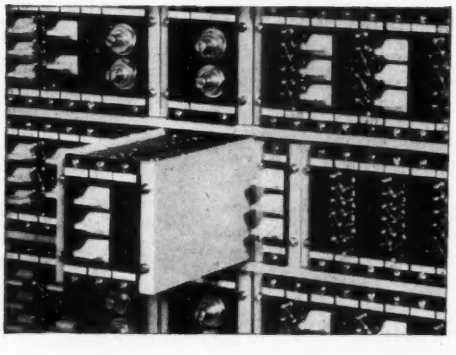


60 channels per bayside . . .

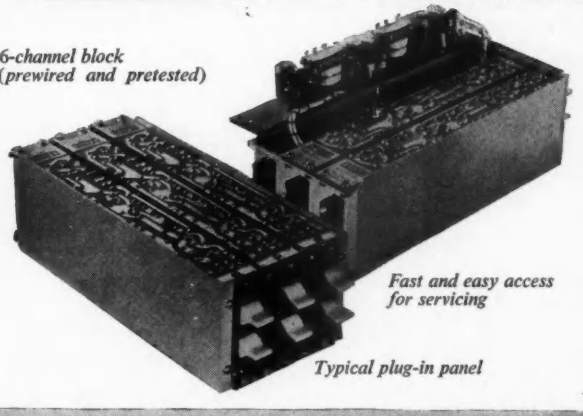
complete with carrier and power supplies

SIEMENS EDISWAN new equipment construction (E.C.3) offers this space saving advantage as well as these other features:

- 120 channel bay from 2 independently mountable baysides bolted back-to-back
- Complete with carrier and power supplies and inbuilt outband signalling
- Plug-in units
- Fully transistorized: designed and built to C.C.I.T.T. standards
- Complete and easy access to all components
- Uses standard 9 ft. by 20½ in. bays, allowing immediate incorporation into existing station arrangements
- Station cabling terminates at each 6-channel block



6-channel block (prewired and pretested)



Fast and easy access for servicing

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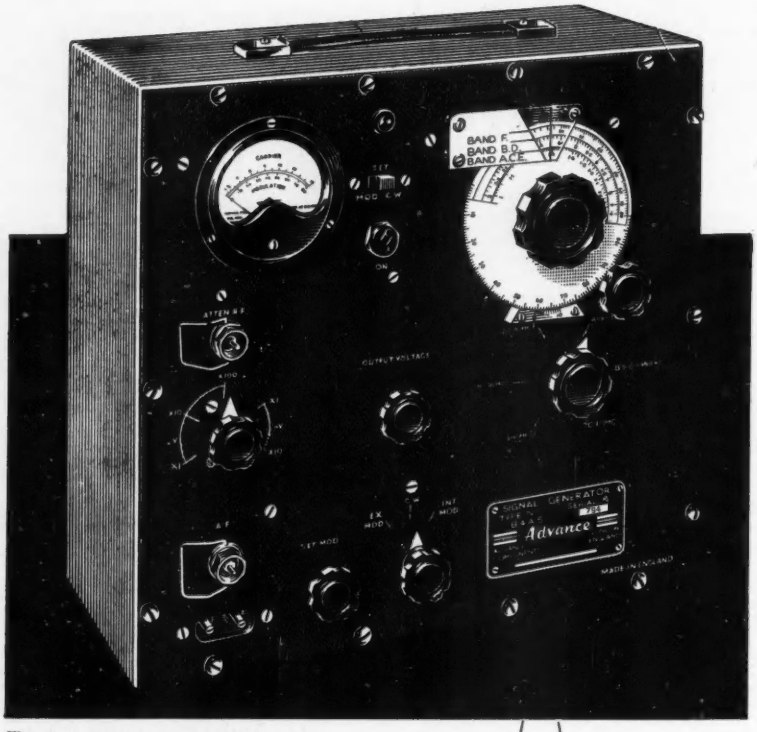
The R.F. SIGNAL GENERATOR



This instrument is now available with an output impedance of 50 ohms.

TYPE **B4**

MODEL A : 100/kcs to 80Mc/s
in 6 bands

MODEL B : 30kc/s to 30Mc/s
in 6 bands

Calibration accuracy of both models is ± 1%

by **Advance** *— to be sure!*

NETT PRICE IN U.K.

£68

Full technical details in Leaflet D38 available on request

The 'Advance' B4 Signal Generator is a well tried and proven instrument which incorporates special features consisting of a monitored R.F. output and variable modulation depth (which is also monitored); an 80 dB attenuator of special design provides exceptional accuracy of attenuation throughout the frequency range and an unusually low leakage factor is achieved by triple screening of the R.F. oscillator, and by mounting the calibrated dial on the outside of the case.

OUTPUT IMPEDANCE:
75 ohms unterminated; termination pad supplied to provide output impedances of 37 and 10 ohms and a dummy aerial facility.

INTERNAL MODULATION:
400c/s ±10% modulation depth 0 to 80% ±10%.

EXTERNAL MODULATION:
MODEL A: 10c/s to 30 kc/s; modulation depth 0 to 80%.
MODEL B: 10c/s to 10kc/s; modulation depth 0 to 80%.

AUDIO OUTPUT:
0 to 10 volts into 600 ohms at 400c/s.
R.F. LEAKAGE: Less than 1 microvolt.

Advance COMPONENTS LIMITED
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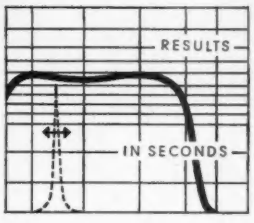
SIEMENS



A Carrier Frequency Measuring Set-up –115 dB to +30 dB:

ONE KNOB SYNCHRONISED TUNING
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Selective measurement of attenuation, return loss and impedance accomplished with same rapidity as wide-band tests using:

Level Oscillator Rel 3 W 29 k (dB version); 29 s (dBm version)

Frequency range	300-5000 c/s, 4-620 kc/s 600-1220 kc/s
Output level	–72 dB to +18 dB

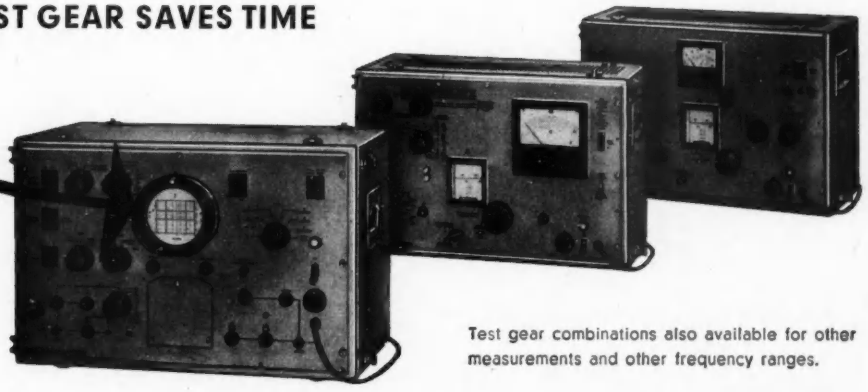
Level Meter Rel 3 D 332 k (dB version); 332 s (dBm version)

Frequency range – wide-band	300 c/s to 1220 kc/s
selective	2 kc/s to 1220 kc/s
Sensitivity – wide-band measurements	–65 dB to +30 dB
selective measurements	–115 dB to +30 dB
impedance measurements	30 to 3000 Ohms

Complete response curves on a CRO can be obtained in conjunction with:

Sweep Drive Rel 3 W 914 and Level Tracing Receiver Rel 3 K 29:
Sweep-scan variable between approx. 10-600 kc/s.

S&H TEST GEAR SAVES TIME



Test gear combinations also available for other measurements and other frequency ranges.

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Finding relays a puzzle?

We're old hands at straightening out relay problems.

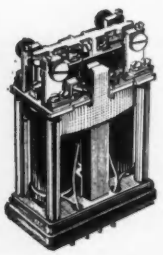
After all, we've been designing and making them for years (over 50 in fact)—big ones, little ones, sensitive ones, general purpose ones; open, dust protected and hermetically sealed, high current, low capacitance, high 'g'—in fact the lot.

We admit that we can't always come up with the answer off the shelf—who can with daily developments in electronics, radar, airborne equipment, nucleonics, reactor instrumentation, etc.? But all of these industries are continually finding Ericsson relays the perfect answer to their problems.

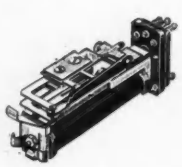
If you are stuck with a very special project and are behind schedule, let us lend you an expert hand.

Help us to help *you*—give us as much information as possible, for an early solution.

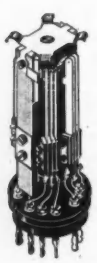
Here are a few of our current miniatures



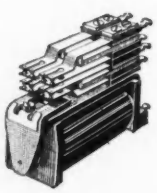
POLARIZED RELAY
Versatile, sensitive and stable. Available with one or two change-over contacts. Dust cover or hermetically sealed. Long or short frame models.



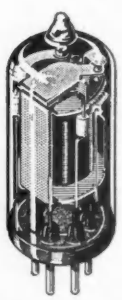
TYPE 1A RELAY
Highly sensitive—non-polarized type with balanced moving system for high 'g' performance. Hermetically sealed. With one change-over.



TYPE 2 RELAY
General purpose type with balanced moving system. Normal and heavy duty contacts up to 4 change-overs. Hermetically sealed.



G.P. RELAY
For general purpose applications. Multi-contacts up to 4 units. Open, dust cover or hermetically sealed with normal, heavy duty or low capacitance contacts.



MGL RELAY
Specially designed for electronic and nucleonic applications. One change-over contact. Fits B7G base. Also available with metal can.

Full details of these and other relays can be obtained from:

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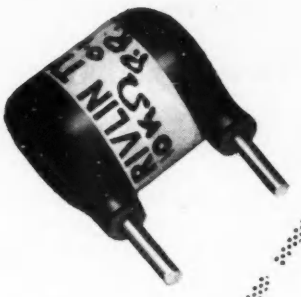
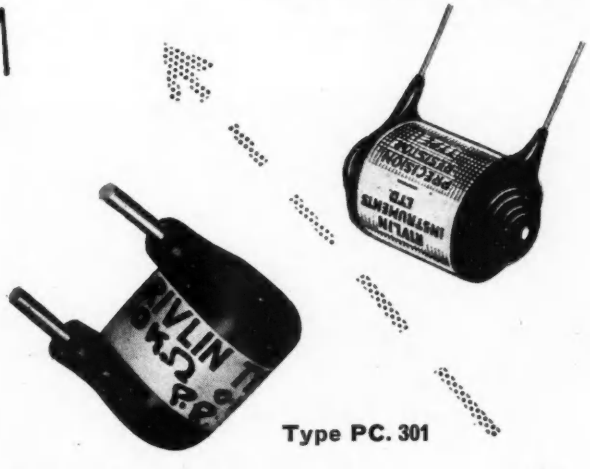


Type 201

Type 201, the newest precision wirewound resistor can be plugged into an Electro Methods type D2 socket. Gold-plated phosphor bronze pins ensure strength with consistent low ohmic contact resistance, while the tough resin encapsulation will withstand extremes of temperature and humidity.

RIVLIN

for high precision resistors



Type PC. 301

The standard range of Rivlin precision resistors are eminently suited to all applications requiring great accuracy, stability and low temperature coeffecient. Supplied to any tolerance up to ± 0.1% of the nominal value, or 0.01Ω, whichever is greater.

Type PC.301, the miniature precision resistor designed specifically for printed circuit use. Phosphor bronze pins, spaced 0.3″ to suit the standard Printed Circuit module, are silver finished for ease of soldering. The PC.301, which is unaffected by extremes of temperature and humidity, is designed to match the rapid development of modern Printed Circuits.

RIVLIN, the name behind the resistors preferred the world over for their accuracy, reliability, craftsmanship and prompt delivery.

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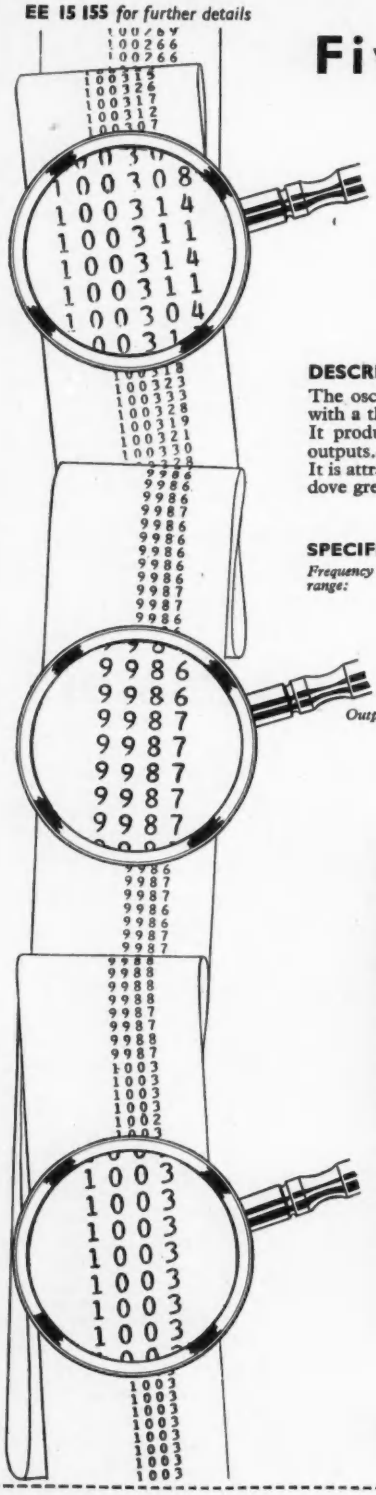

Five years ago
THE WINSTON SEMI-DECADE OSCILLATOR

was designed for use in the development laboratories and test department at our works. It was found to be such a useful instrument that it was decided to produce it in quantity. By advanced production techniques we are able to offer this instrument at a most competitive price.

DESCRIPTION

The oscillator uses an R.C. Wien bridge circuit with a thermistor controlling amplitude stability. It produces independent sine and square wave outputs.
It is attractively styled in smoke grey cabinet with dove grey front panel.

SPECIFICATION

Frequency range: 10 c.s. to 100 Kcs. in four main ranges with slow-motion vernier dial for setting a continuously variable frequency within the main ranges. The dial is engraved with both direct reading and vernier, for more accurate resetting. Calibration accuracy 1%.

Output: Sine wave variable from 0-10v peak, adjustable with a high impedance variable attenuator and divider switch giving ratios of x1, x0.1, x0.01, x0.001 attenuation. Total content of harmonics and hum is less than 1%. Square wave of fixed amplitude of 10v ±5% maximum drop at 10 cps. is 2%. The rise and fall time at 100 Kcs. is 1 micro sec.

Amplitude stability: Output stability, ±1% at any frequency.

Frequency stability: Better than 1%.

Power supply: 100-120V, 200-250V 50-60 cycles.

Terminals: Concentric sockets for sine and square wave outputs.

Accessories supplied: Mains lead. Coaxial Output Plug.

Dimensions (overall): Width 15" (37.5 cms.)
Height 10¼" (25 cms.)
Depth 8¾" (22 cms.)
Weight 18 lbs. (8 Kgs.)

Price £48-10-0

Facsimile of stability checks on the oscillators using a Berkeley Universal Counter/Timer Type 7360 and a Berkeley Digital Recorder Type 1452. Checked at 100 Kcs., 10 Kcs., and 1 Kc over a period of 24 hours.

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Walton-on-Thames 26321

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we can get you out of a rectifier problem

We, that's the M-O Valve Co. Ltd., have spent over 40 years bottling up hard valves, soft valves, tough going-aloft valves, standard valves, valves to government specs . . . so we know how you feel in there.

But we're used to it, because now we've acquired a rare collective know-how that can beat most valve problems. And of course, it's backed by the brilliant research, progressive development and flexible production you'd expect us to have.

Next time you're enveloped in a valve problem, let us know—if we haven't a ready-made type for you, we'll see if we can make you one to measure.

XENON FILLED TYPE. *The G.E.C. range will keep going a long time—and has better PIV safety ratings too.*

MERCURY VAPOUR TYPE. *We've had over 30 years of know-how in making this type of rectifier. As you'd expect, they're the best you can get. There's a range of eight.*

VACUUM TYPE. *Too many even to give you an outline. (Bi-phase, full-wave, high voltage, special quality, 450 to 28,000V rms.)*

Let us know what types you're interested in and we'll send you full details.

G.E.C. valves are obtainable from

THE M-O VALVE CO. LTD

BROOK GREEN · HAMMERSMITH · LONDON W.6.

A subsidiary of the General Electric Co. Ltd

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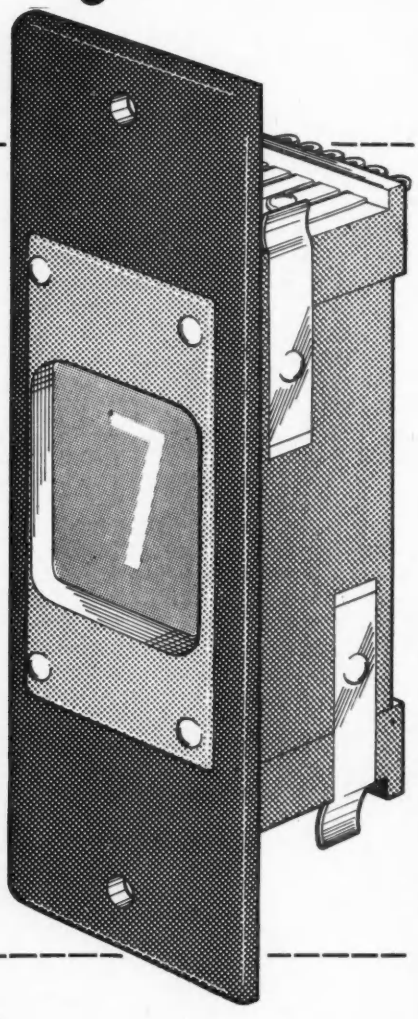
Thorn read-out systems

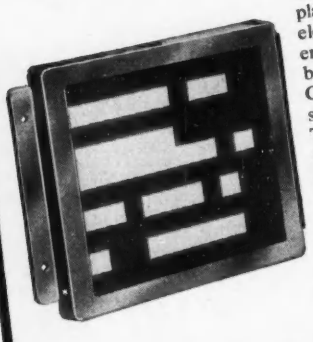
for digital computors



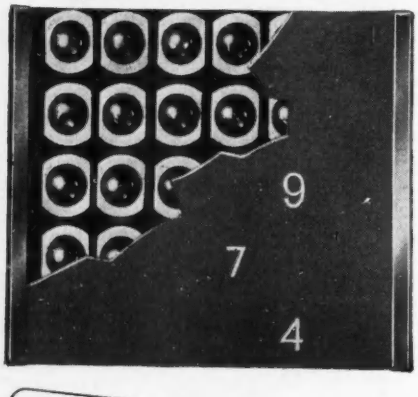
EDGE-LIT INDICATOR

Simple unit structure, easy relamping, robust in-line solder tag connections, 12 circuits. Display includes numerals 0–9 with decimal point (which may be illuminated with two lamps) or with plus and minus signs. Thorn Midget Panel Lamps, in voltage ratings of 28, 12, 6 or 4 (AC-DC) are used to illuminate the characters. Can be supplied separately or with ancillary relay equipment for complete readout system. Overall dimensions $1\frac{1}{8}$″ deep x $4\frac{3}{4}$″ long x $1\frac{3}{8}$″ wide.

ELECTROLUMINESCENT INDICATOR BLOCK

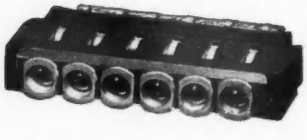


The device is a slim glass plate with an array of 100 electroluminescent spots energised from a printed circuit bonded to the rear face. Characters can be built up by suitable combinations of connections. The current consumed by each illuminated spot is a fraction of a milli-amp, the voltage required being of the order of 300 volts with a frequency range of up to 400 c.p.s. It is available as a separate component or as part of a complete read-out system. Overall dimensions:— 3.500″ x 3.000″ x .265″.



MULTIPLE LAMPHOLDER

When mounted in banks, the Thorn Multiple Lampholder (below) provides a clear legible read-out through variation in the pattern of illuminated Midget Panel Lamps. The bank of Lampholders can be overlayed with a sheet of "Plasteck" on which the desired characters are engraved—each character lining up with one filament. The cut-away illustration (left) shows the read-out system provided by this arrangement. Overall dimensions:—0.430″ x 2.475″ x 1.250″ inc. terminals.



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GREAT CAMBRIDGE ROAD ENFIELD MIDDLESEX TEL: ENFIELD 5353

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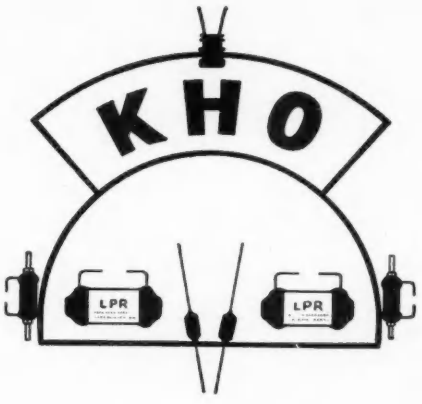

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OTHER TYPES made to order, e.g. American equivalents, miniatures, types for printed circuits; resistors of greater accuracy, greater stability, higher values, lower temperature coefficients, etc.

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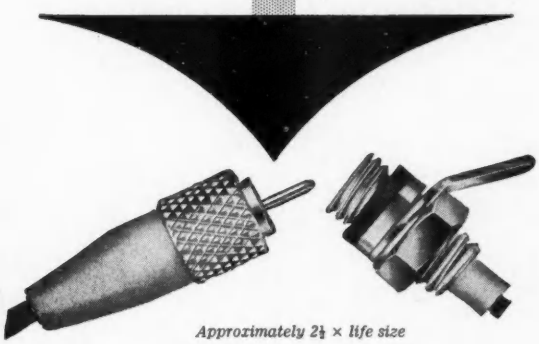


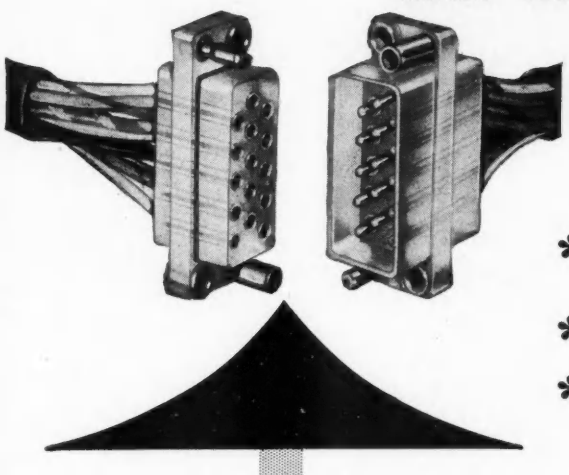
Approximately 2½ × life size

As a contribution towards increasingly compact equipment, Plessey have introduced this new, highest quality and fully comprehensive range to allow a new approach on applications hitherto restricted by the limitations of existing connectors.

Designed for the matched impedance coupling of high frequency coaxial cables operating in the super high frequency bands, these connectors—

* have a working voltage of 650 volts PEAK at sea level, and matched impedance coupling of 50 ohm lines is accommodated.
* have hard gold plated contacts on silver plate to give maximum performance with minimum voltage drop.

SERIES '110' (15- and 30-way) MINIATURE RECTANGULAR CONNECTORS



Developed specifically by Plessey to meet the demand for a safe, inexpensive connector for commercial applications, this new series embodies excellent electrical and mechanical characteristics, and the many unique features that make it really outstanding include:—

* Plug pins and socket inserts are polythene shrouded to dispense with gaskets and ensure insert anchorage.
* Mismating is prevented by corner pins and corner sockets.
* Extreme simplicity of wiring, demands less-skilled operation than the orthodox methods of soldering pins *in situ*.

For further information please write for Publication Nos. 128 and 114

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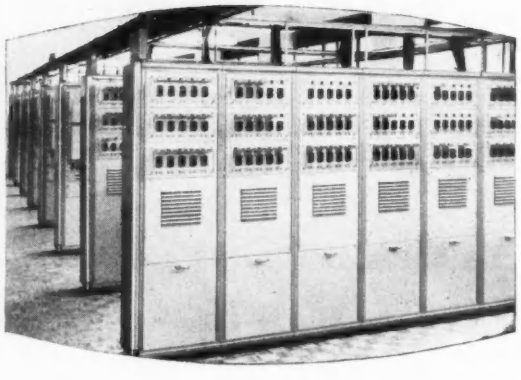
We will gladly co-operate with your technical department in development work involving the use of Relays.



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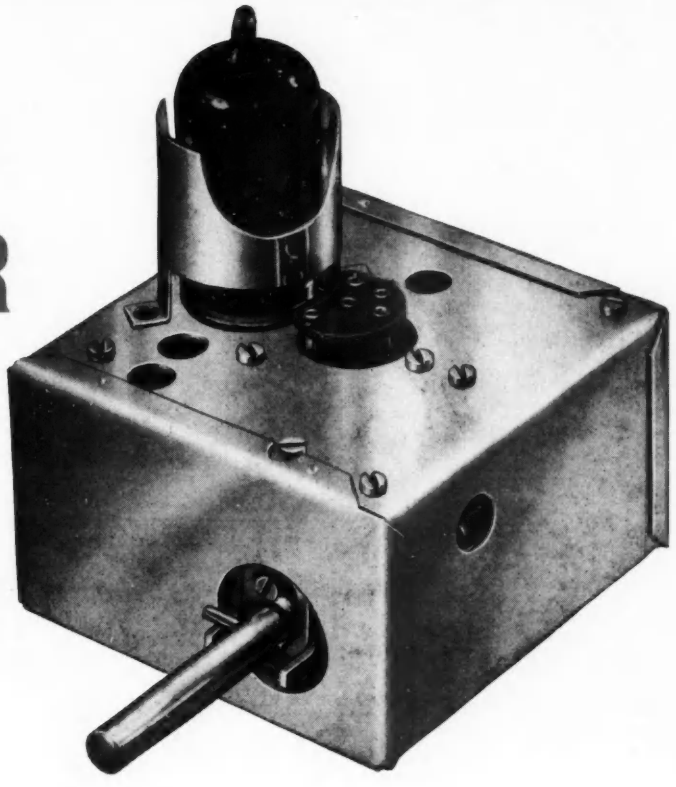
Cyldon COMPONENTS

NEW
PRINTED CIRCUIT
F. M. TUNER



The Cyldon Printed Circuit F.M. Tuner, with its unique design and construction, offers the optimum performance obtainable with a double triode valve.

Using a double triode valve with one section as the R.F. amplifier and the other as a self-oscillating mixer, this tuner has the following design features:-

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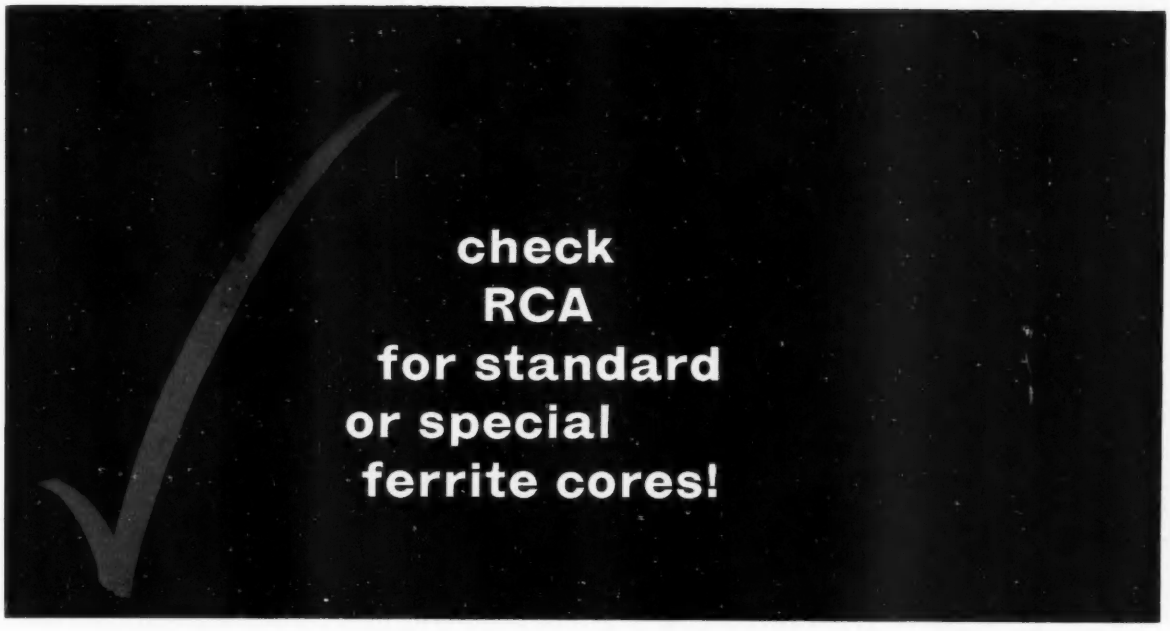


. . . for a wide range of computor applications!

Now—commercially available from RCA—a comprehensive line of fast-switching, low- and high-drive, memory cores and several new memory-plane designs to provide equipment designers with one of the broadest lines of memory core products in the industry.

MEMORY CORES

In addition to a line of standard ferrite cores developed for coincident-current memory applications (ranging in switching time from 0.2μ sec. to 3μ sec.), RCA now offers a new group of ferrite cores particularly suited for both high-speed, word-address memories, and slow-speed, low-drive coincident-current memories. These cores are available for an applied field (H_0) ranging from 0.2 to 1 oersted, and in sizes from 0.050″×0.030″ to 0.370″×0.290″. The smaller-size cores make possible the design of high-speed memory devices with driving currents suitable for either transistor or valve drivers. Typical characteristics are given in the table.

MEMORY FRAMES

A compact, rugged aluminium frame utilizing a new stack-wiring concept makes possible a "bit-packing factor" greater than ever before. 8,192 bits may be stored in a 7″×7″×0.3″ frame. For more economical designs and even greater compactness, a laminated frame accommodating 8,192 bits in a $5\frac{1}{2}$″×$5\frac{1}{2}$″×$\frac{1}{4}$″ space (including terminals) is also available.

FERRITE APERTURE PLATES

RCA's apertured-plate construction utilizing ferrite-core material having low-drive, medium-speed characteristics, can store 256 bits of information in a space less than 0.9″×0.9″×0.025″, thus making possible the design of compact memories for transportable equipment in which minimum weight and space are vital considerations.

The aperture memory plates have a nominal full driving current requirement of 320 ma., a switching time of about 1.8μ sec., and an undisturbed output (1) signal (uV_1) of greater than 40 mv. making them especially suitable for use in transistorized circuits. In addition, the precision registration of the holes makes it possible to stack the aperture plates quickly and accurately.

Rigid production controls insure excellent uniformity of undisturbed output signal and peaking time . . . testing assures dependable performance of each storage element.

Typical Characteristics of Ferrite Cores for 2:1 Coincident-Current Applications

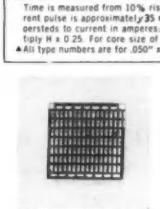
RCA Type▲	T_s μ sec.	T_p μ sec.	uV_1 mv.	dV_2 mv.	Driving Current ma. (I_m/I_{2m})	T_r μ sec.
XF-3806	.27	.13	160	26	1100 660	.12
XF-4019	.67	.32	106	14	725 450	.12
XF-3018M	1.18	.53	55	9	460 275	.20
XF-4028	1.08	.60	72	4	380 190	.50
XF-3973	1.28	.71	48	5	350 215	.40
XF-3673	2.80	1.35	22	4	210 126	.50
XF-4003	2.60	1.45	24	3	190 95	.50
XF-4004	2.36	1.26	26	5	190 95	.50
XF-4005	4.10	2.35	10	5	125 63	.50
XF-4006	9.0	4.8	4.5	4.5	90 45	.50
XF-4007	7.5	4.3	4.5	5.0	70 35	.50
XF-4008	13.0	6.5	2.0	3.5	40/20	.50

Time is measured from 10% of current rise to 10% of voltage (uV_1) fall.
▲All type numbers are for .050″ x .030″ x .015″ size.

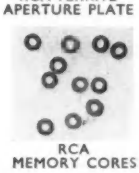
Typical Characteristics of Ferrite Cores for Switching Applications
Switching Time (T_s) μ sec. vs. Applied Field (H_0) in oerstds

RCA Type▲	Switching Time (T_s)—μ sec. H_0=.5	H_0=1.0	H_0=1.5	H_0=2.0	H_0=3	H_0=4	H_0=5
XF-3806						.22	.18
XF-4019					.41	.24	.163
XF-3018M			1.12	.75	.36	.226	.161
XF-3973			.73	.47	.22	.138	.105
XF-3673		1.16	.63	.40	.22	.15	
XF-4003		1.04	.60	.39			
XF-4004	3.84	.90	.52	.34	.194	.129	
XF-4005	3.69	.81	.48	.312	.174		
XF-4006	2.36	.71	.41	.260	.142		
XF-4007	1.38	.48	.28	.194			
XF-4008	1.53	.41	.242	.165			

Time is measured from 10% rise to 10% fall of uV_1. Rise time of current pulse is approximately 35 millimicro-seconds. To convert drive in oersteds to current in amperes: For core size of .050 OD x .030 ID, multiply H x 0.25. For core size of .080 OD x .050 ID, multiply H x 0.41.
▲All type numbers are for .050″ x .030″ x .015″ size.


RCA FERRITE APERTURE PLATE

RCA MEMORY FRAME


RCA MEMORY CORES

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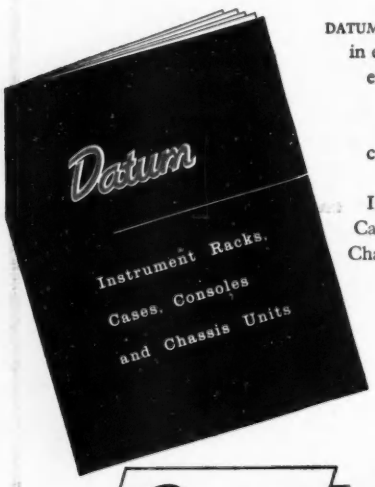

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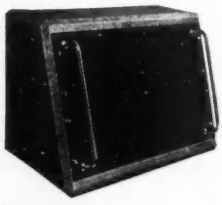

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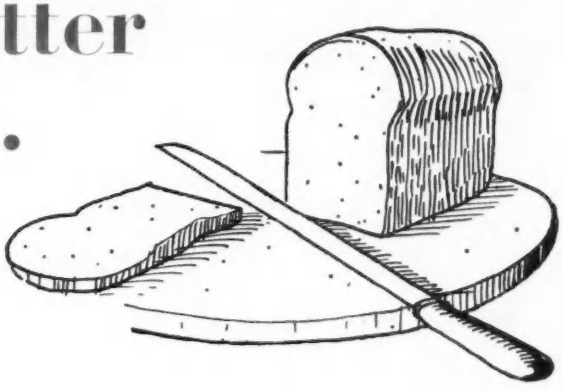

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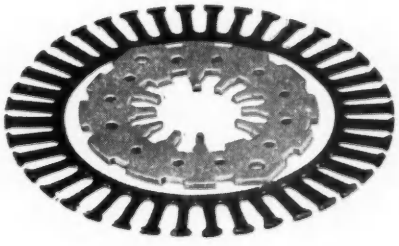

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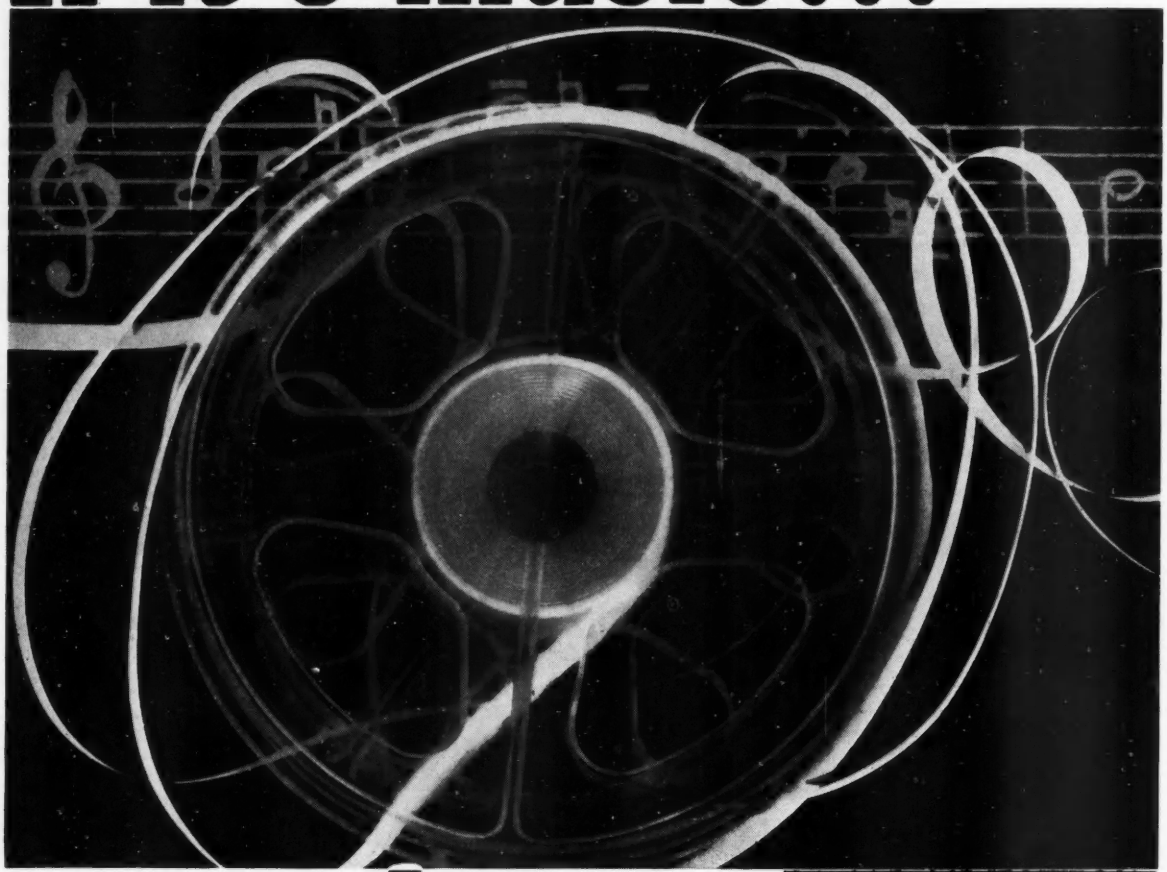

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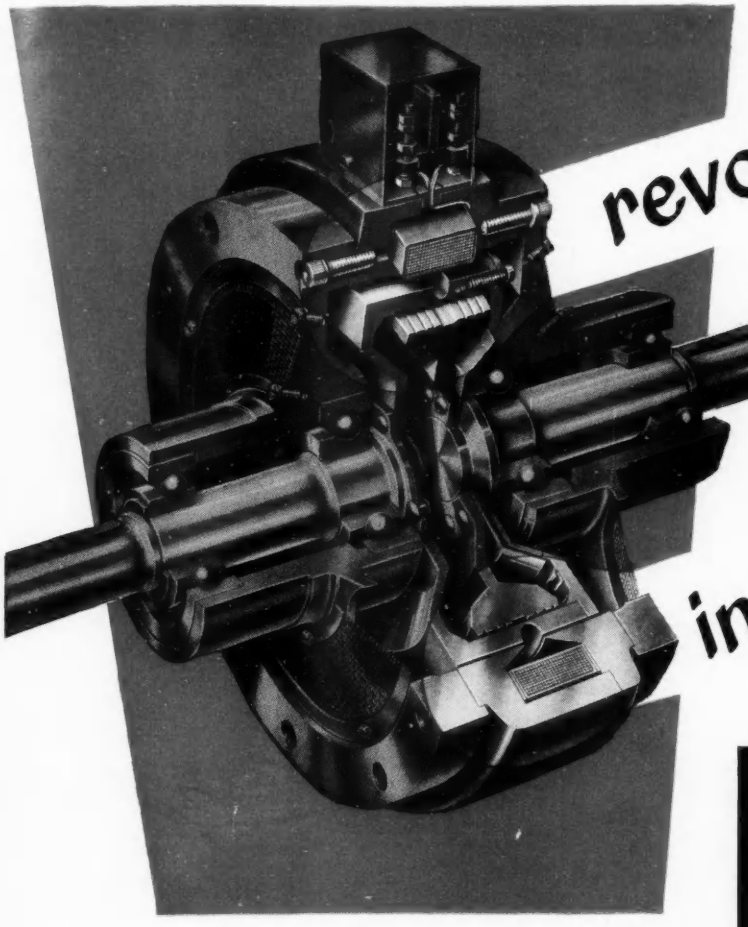

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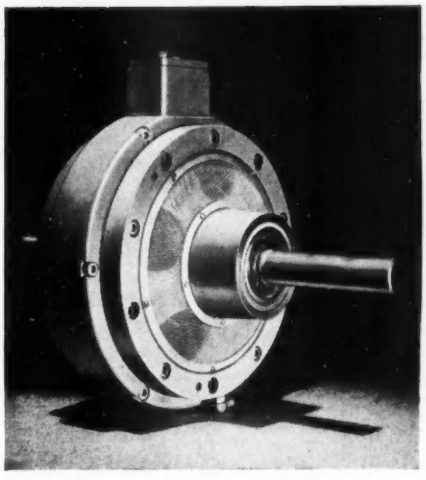

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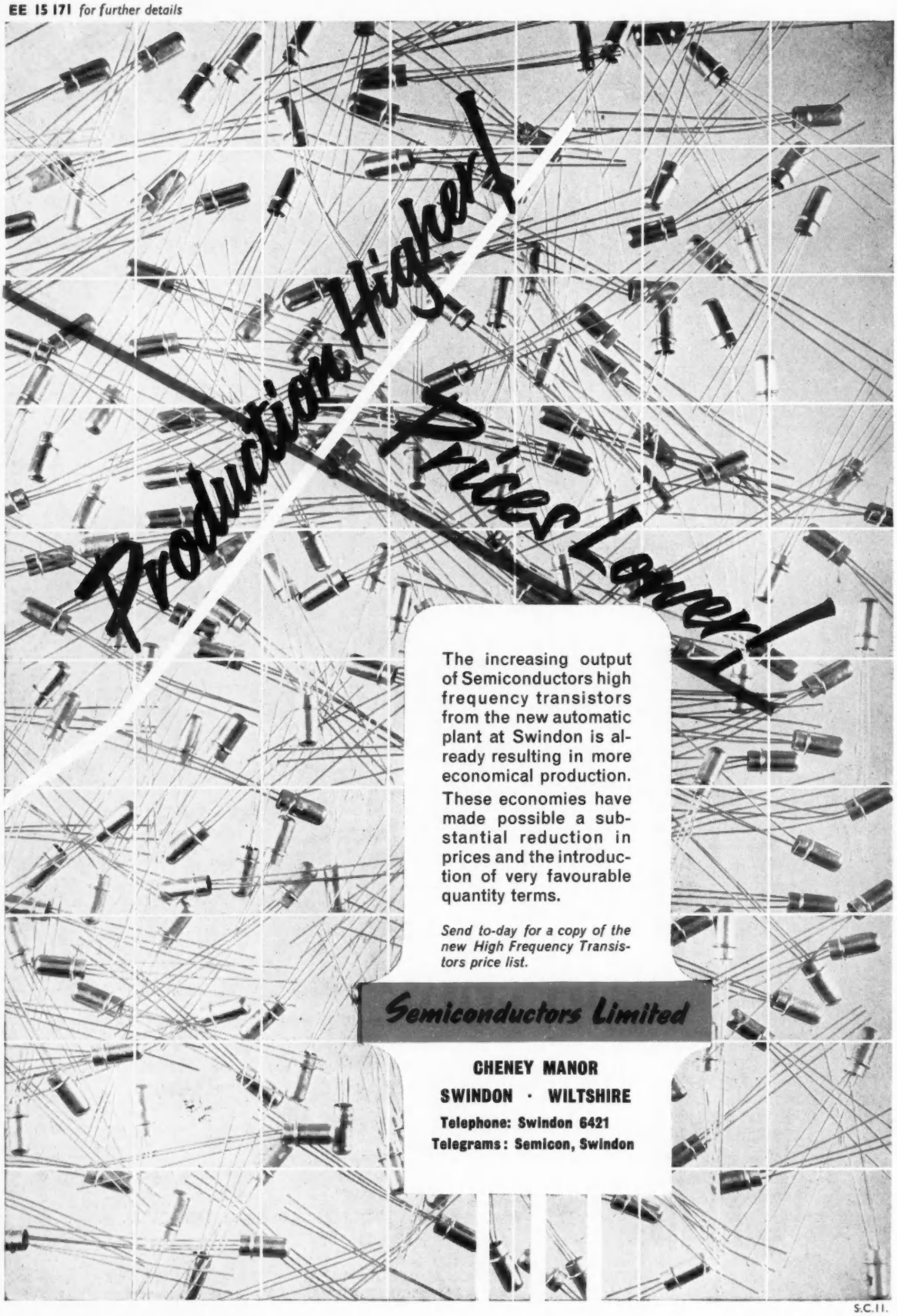

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Type N 101

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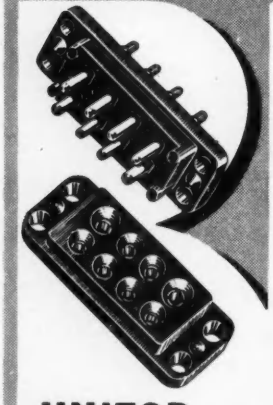

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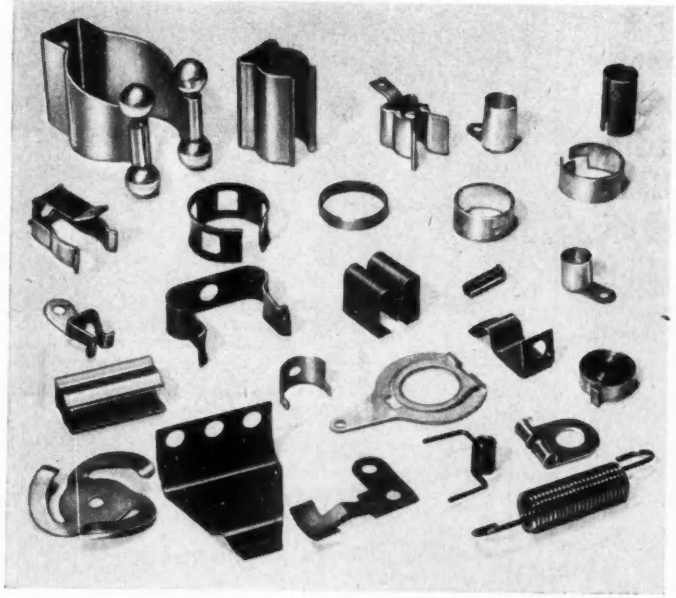

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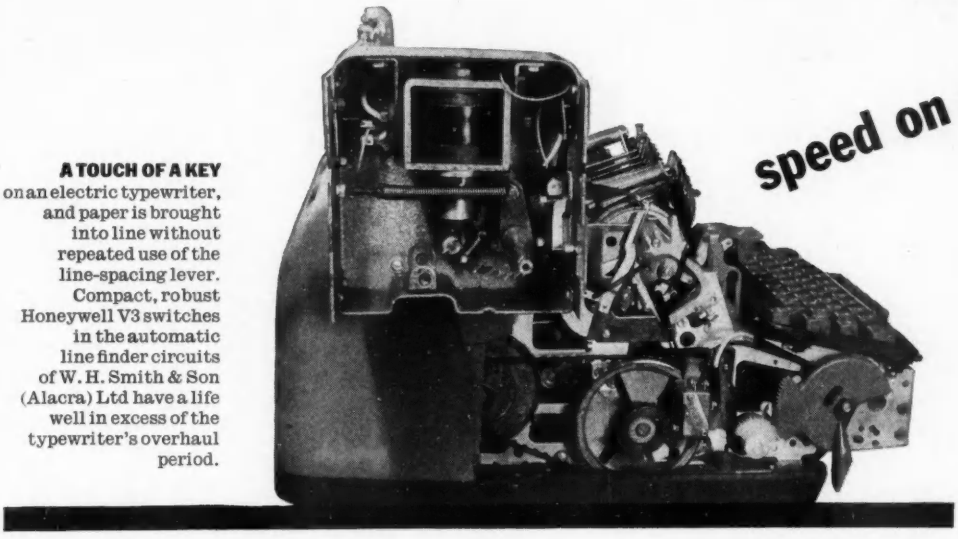

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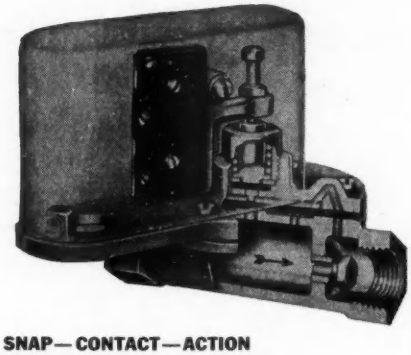

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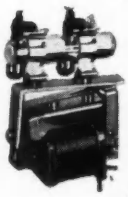

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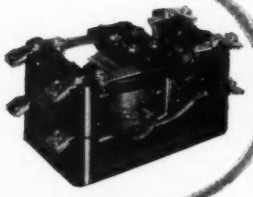

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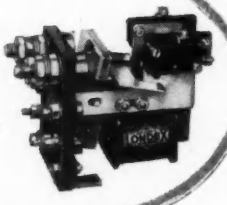

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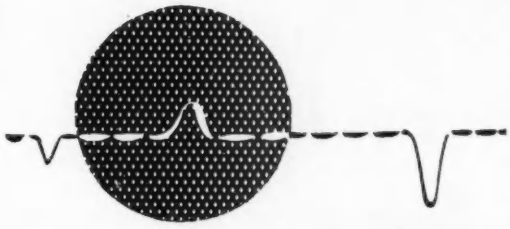

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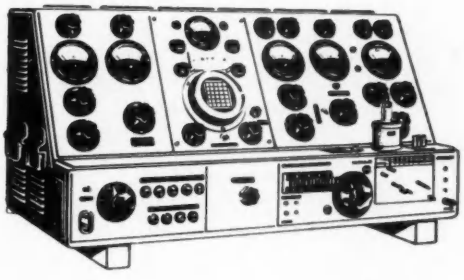

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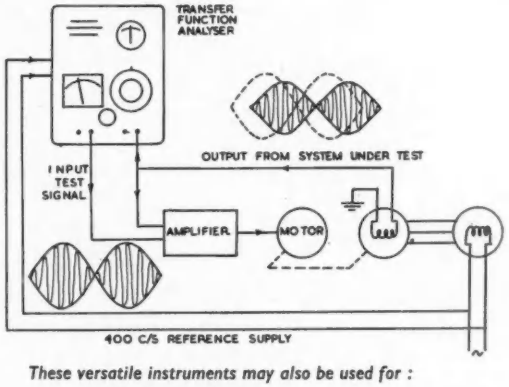

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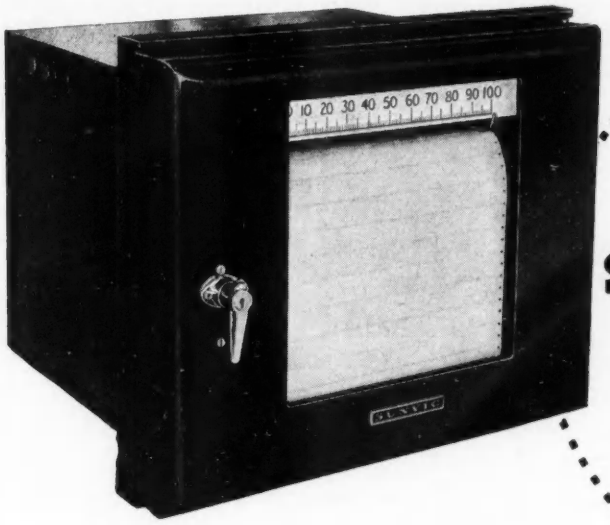

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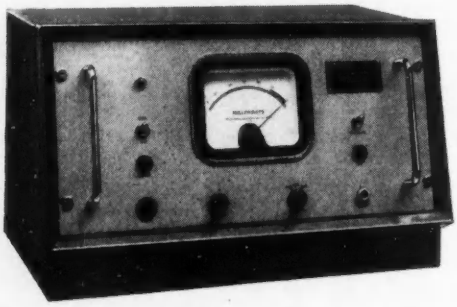

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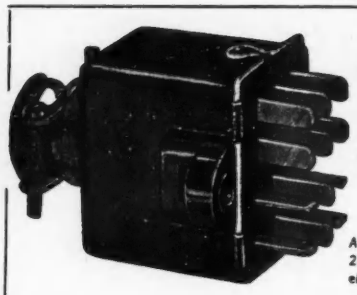

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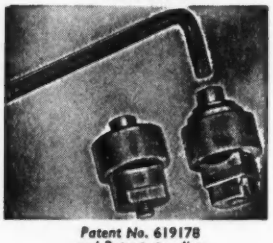

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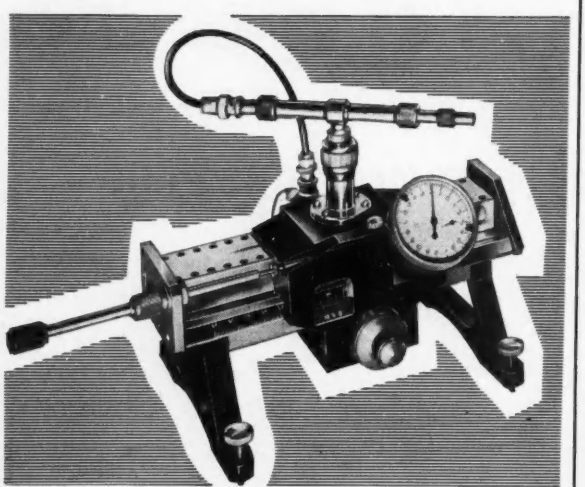

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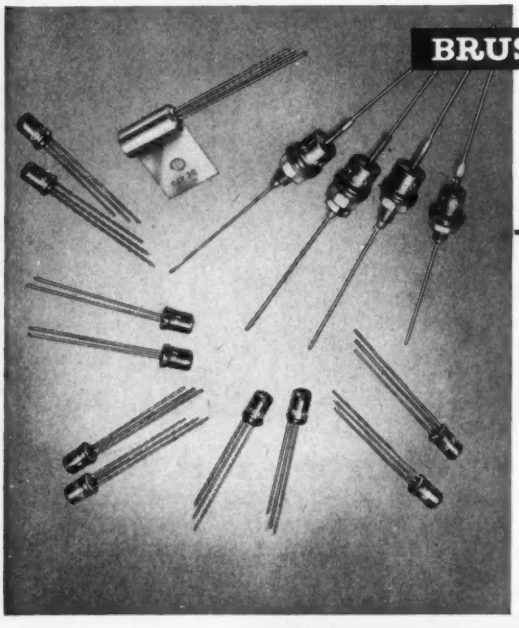

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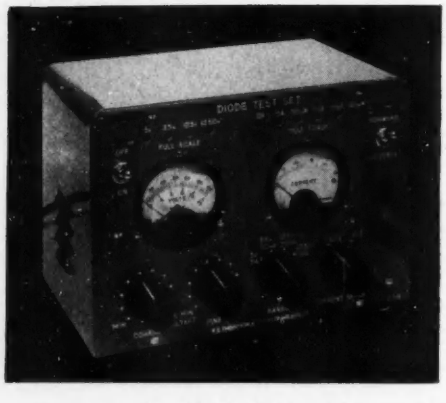

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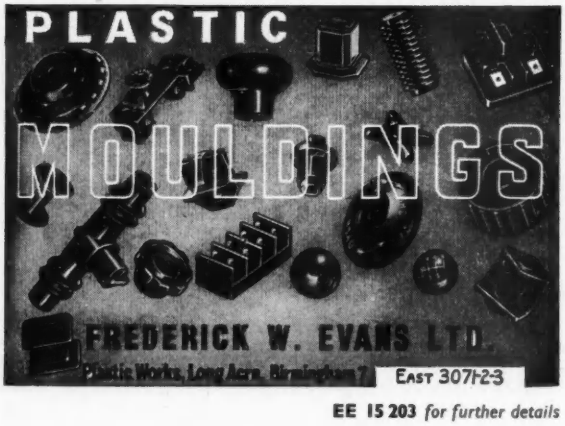

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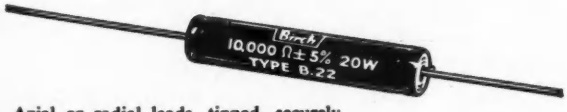

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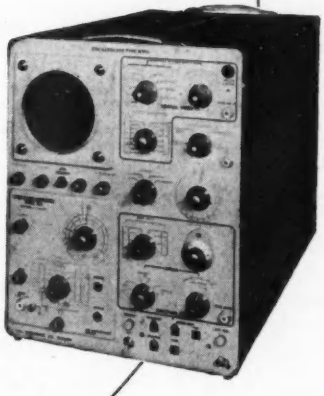
To limit temperature rise in their type WM16 oscilloscope a Woods fan is included in the specification by E.M.I. ELECTRONICS.



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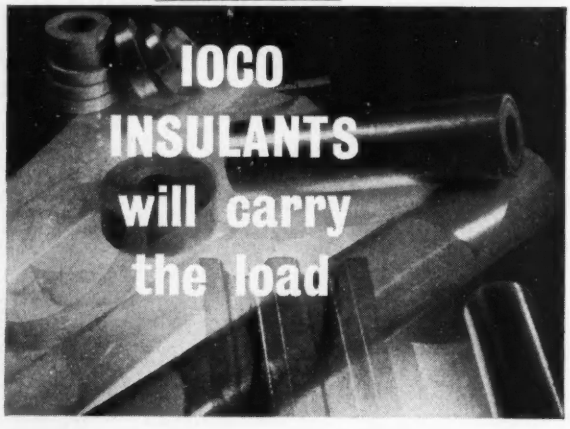

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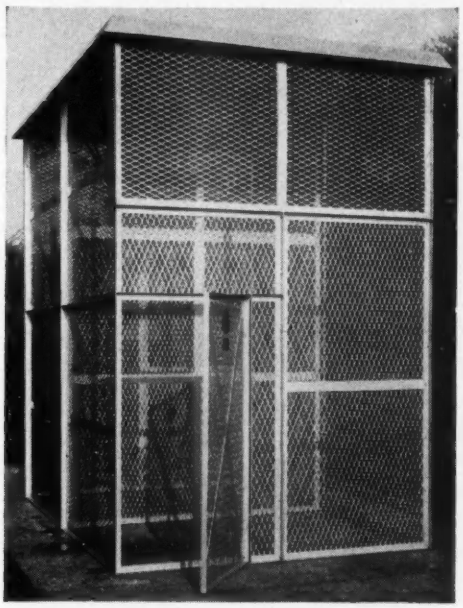

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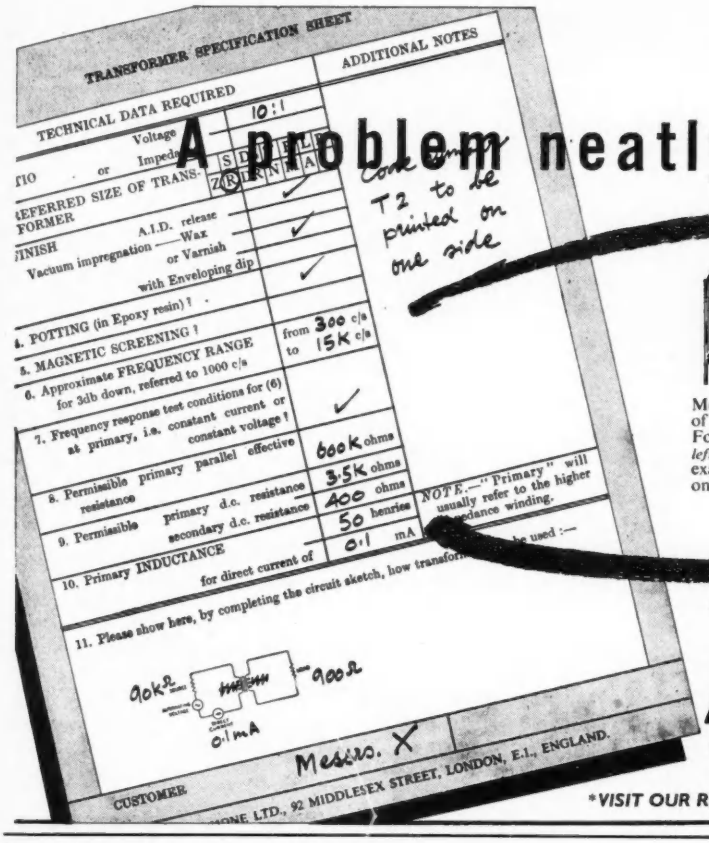
TRANSFORMER SPECIFICATION SHEET
TECHNICAL DATA REQUIRED
ADDITIONAL NOTES
Voltage — 10:1
Impedance or
REFERRED SIZE OF TRANS-FORMER
FINISH
A.I.D. release
Vacuum impregnation — Wax
or Varnish
with Enveloping dip
4. POTTING (in Epoxy resin) †
5. MAGNETIC SCREENING †
6. Approximate FREQUENCY RANGE for 3db down, referred to 1000 c/s
from 300 c/s to 15K c/s
7. Frequency response test conditions for (6) at primary, i.e. constant current or constant voltage †
8. Permissible primary parallel effective resistance
600K ohms
9. Permissible primary d.c. resistance
3.5K ohms
secondary d.c. resistance
400 ohms
10. Primary INDUCTANCE
50 henries
for direct current of
0·1 mA
11. Please show here, by completing the circuit sketch, how transfor
NOTE.—"Primary" will usually refer to the higher impedance winding.
be used :—
90kΩ
900Ω
0·1mA
Messrs. X
CUSTOMER
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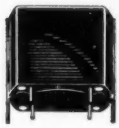

Messrs. X. wanted this special type of transformer . . . with the help of a Fortiphone specification sheet *(on the left)*, and our vast experience, his exact requirement was provided in only a few days.

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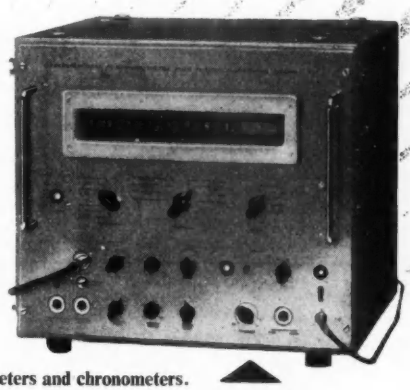

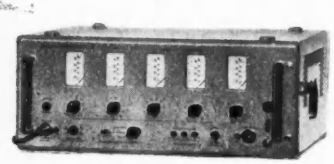

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10 microsec to 27 hrs.	Time intervals ..	0.1 microsec to 2700 hrs.
± 5 in 10^8	Crystal accuracy ..	± 5 in 10^7

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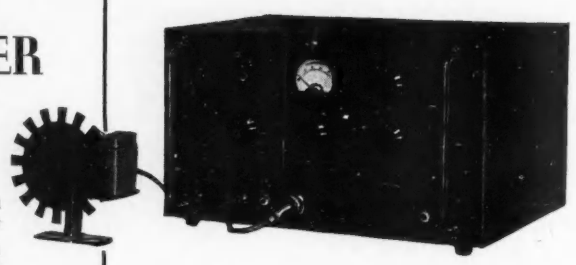
SPECTROMETER AMPLIFIER

& CHOPPER UNIT



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25 watt instrument model (Illustrated)

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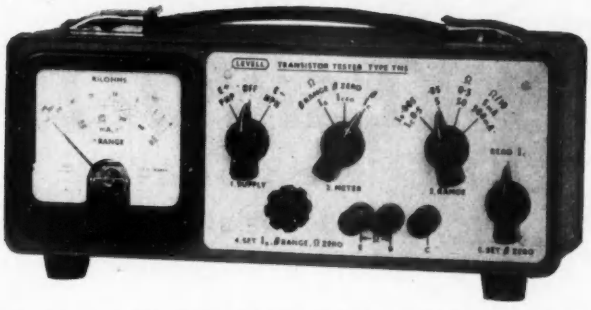
TRANSISTOR TESTER TYPE TM5



Measures the current gains of PNP and NPN transistors, the values of resistances, and the leakage currents of diodes, transistors, and low voltage electrolytic condensers

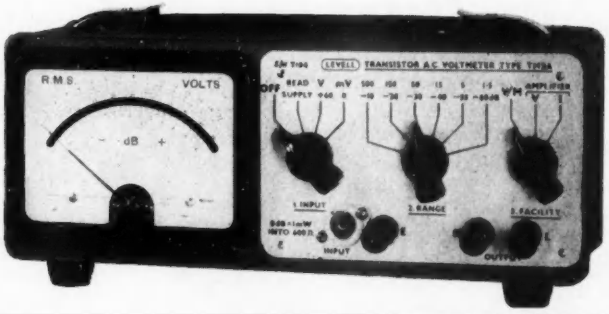
Collector Current Ranges	:	0.5, 5, 50, 500 mA
Current Gain Ranges	:	100, 250, 500
Resistance Ranges	:	0–50k Ω, 0–500k Ω
Price with batteries	:	**£17.0.0**

MULTITESTER TYPE TM1

Transistors and transistor circuits may be tested with this instrument. It contains a transistor 1 kc/s oscillator and a sensitive transistor A.F. voltmeter of 150mV f.s.d. The A.C. current gains of PNP and NPN transistors may be measured at D.C. currents from 0.5mA to 0.5A. Provision is also made for measuring the leakage currents of transistors, testing diodes and resistances, measuring D.C. and audio voltages and the oscillator output.

Price with batteries **£33.1.6**

A.C. MILLIVOLTMETER TYPE TM2A



Measures 50μV to 500V on 12 ranges from 1.5mV f.s.d. Response ±3dB from 6c/s to 250kc/s, ±0.1dB from 30c/s to 30kc/s. Input impedance 1.8M Ω and 20pF on 1.5V to 500V and 0.5M Ω min. and 65pF max. on 1.5mV. Output for C.R.O. Gain up to 80dB available as amplifier with 2V output. Low noise level. Low microphony. No hum. Price with batteries: **£36.0.0**

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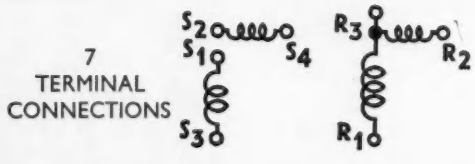
Output is a sine and cosine expression of rotor angular position. Applications include the rotation of rectangular co-ordinates or interchange of rectangular and polar co-ordinates in computer work and precision phase shifting.

Type 11R13N4 high impedence
Type 11R2N4 low impedence

Electrical Characteristics	11R13N4	11R2N4
Input voltage at 400 cycles, volts	26	26
Input current, milliamps	20	52
Input power, watts	.15	.34
Transformation Ratio	0.846	0.490
Voltage gradient volts/degree	.38	.22
DC resistance rotor, ohms	200	14
DC resistance stator, ohms	130	76
Phase shift degrees	7°	10°
Residual voltage total, millivolts	58	27
Residual voltage fundamental, millivolts	38	17
Electrical Error, minutes	7 max.	7 max.



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Philips D.C. Microvoltmeter GM.6020 measures 10μV to 1000V D.C. in 22 ranges, and direct currents from 10μμA up to 10μA. Pointer deflection is independent of polarity, which is automatically indicated by 2 pilot lamps. GM.6020 can be used as a sensitive galvanometer.
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Measuring range: 100μV — 10V f.s.d. at an input resistance of 1 megohm. 10mV — 1000V f.s.d. at an input resistance of 100 megohms.
Overall accuracy: 100μV range: ± 5% (relative)
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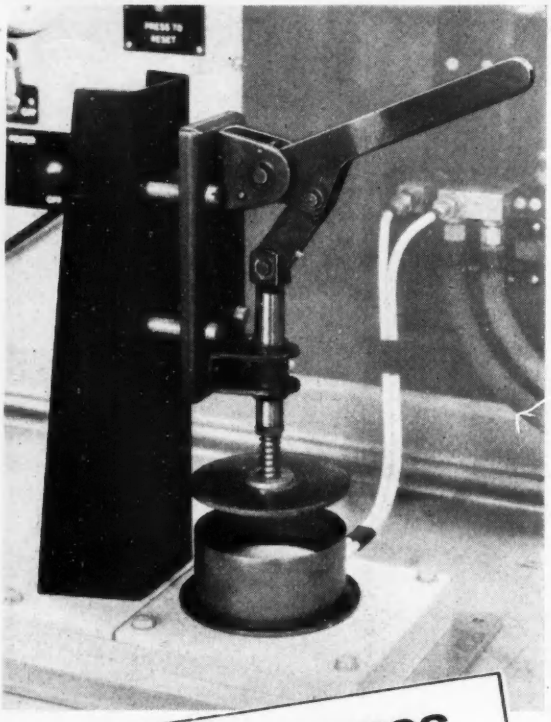

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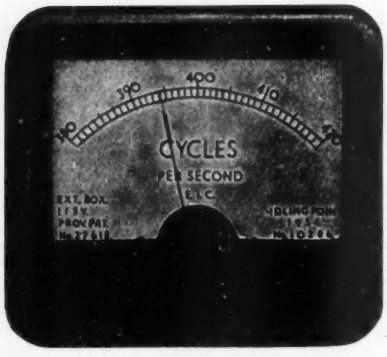

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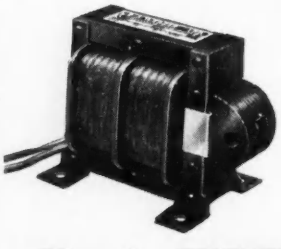

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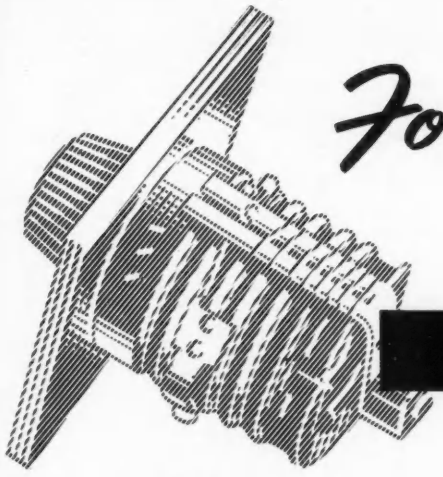

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Moment of inertia of relay armature	3.8 × 10.7 slug ft 2
Stiffness factor of relay armature	0.196 lb.ft/radian
Damping factor of the relay armature	1 × 10-4lb.ft/ rad/sec
Torque constant of the relay	10.2 lb./ft/amp.
Back E.M.F. constant of the relay	14.3 volts/rad/sec
Coil impregnation	Solventless varnish

TYPE MARK E.13

A new development which has an almost identical performance to the Mark E.12, but is designed as a split pole piece assembly and a bobbin type coil which is a separately encapsulated assembly. This unit is offered as being climatically superior.

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Constructionally as Mark E.12 but windings are on a special type core and this unit has a torque of 27 inch/amps at 10 mA.

TYPE MARK E.16 This is a solventless varnish impregnated design giving the following performance:

Standard coil resistance	10,000 ohms
Inductance of windings	Not less than 10H at 750~
Insulation	Not less than 20 megohms at 500 volts
Flash Test	1,000 volts 50 cycles between windings and poles
Angular Movement	Not less than 4° either side of natural centre
Deflexion Current, Full Torque Output	Not more than 7 mA for 850 gm/cms
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Resonant Frequency	Approximately 400 cycles

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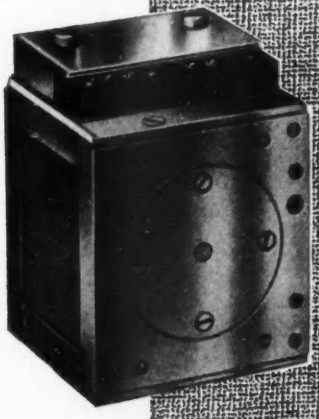
This is a larger unit weighing 4 lb. 3 oz. Size 4¾" × 4" × 4" and giving the following figures:—

Linear torque output	120mA max. for 96 oz/inch
Angular Movement	±7° Natural centre
Resistance	630 ohms per side
Inductance	700 MH (unmagnetized)
Coil impregnation	Solventless varnish

Illustrated is the TYPE T.M.12 which can be used as an actuator/convertor between electronic servo or magnetic amplifiers and hydraulic, pneumatic or direct mechanical linkages.



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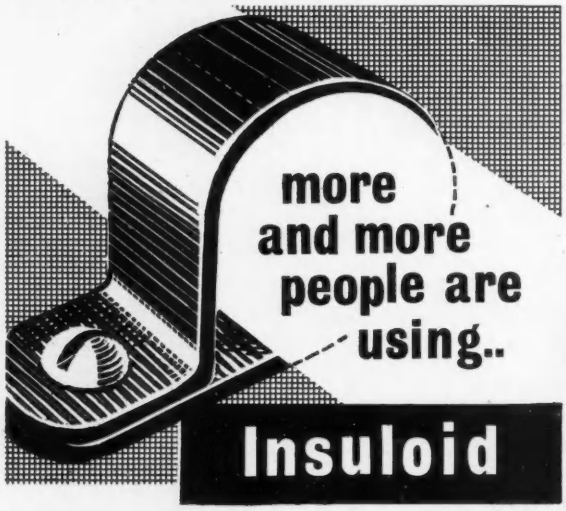

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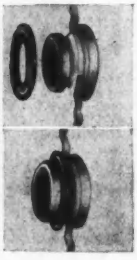

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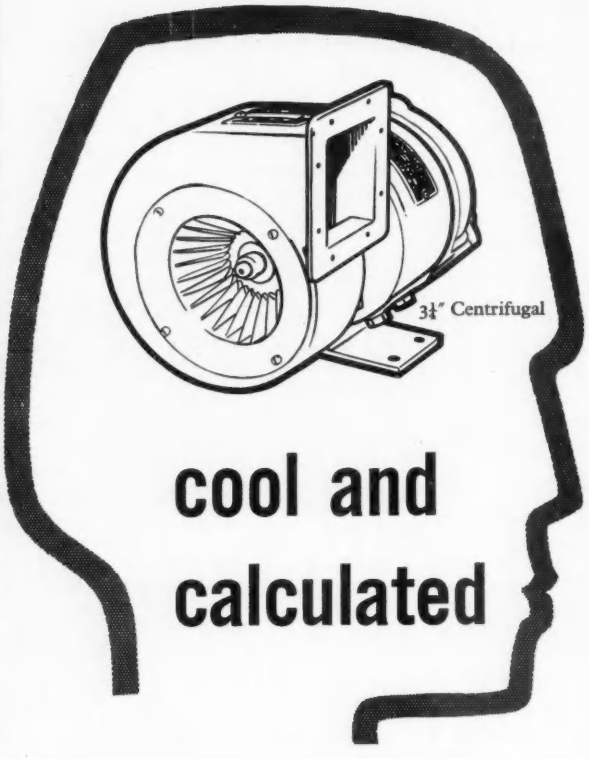

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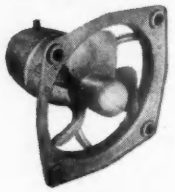

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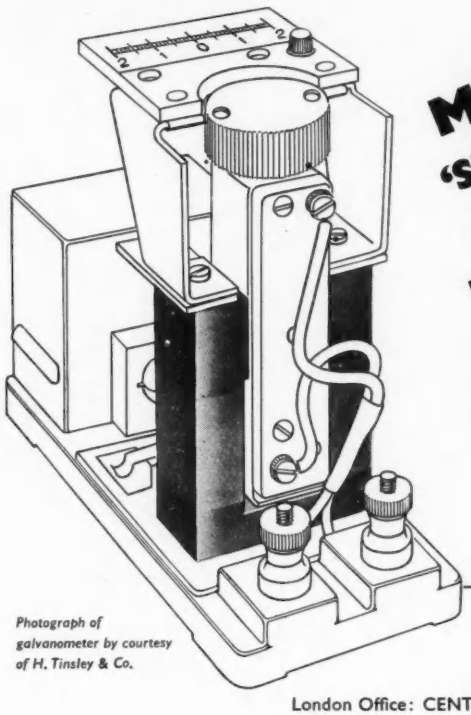

Photograph of galvanometer by courtesy of H. Tinsley & Co.

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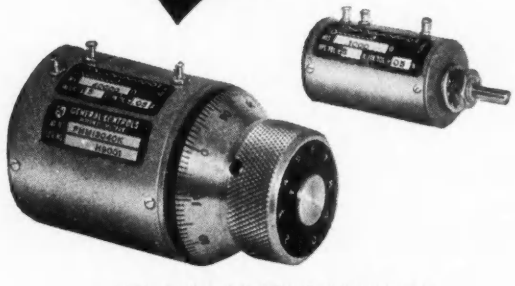

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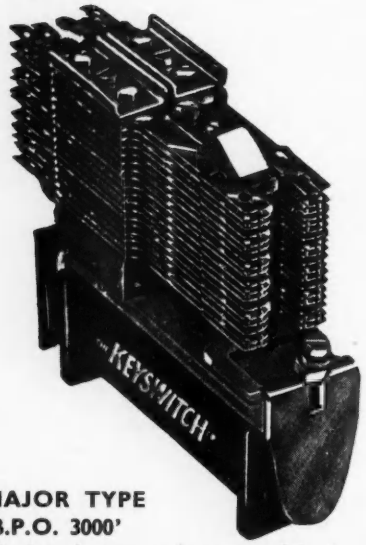

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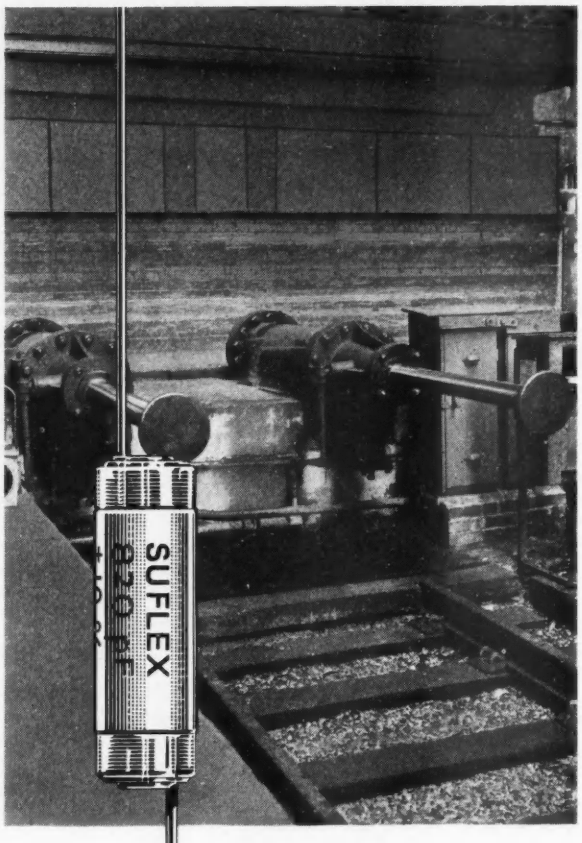

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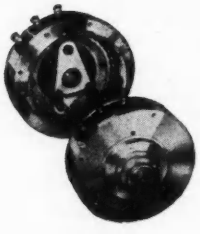

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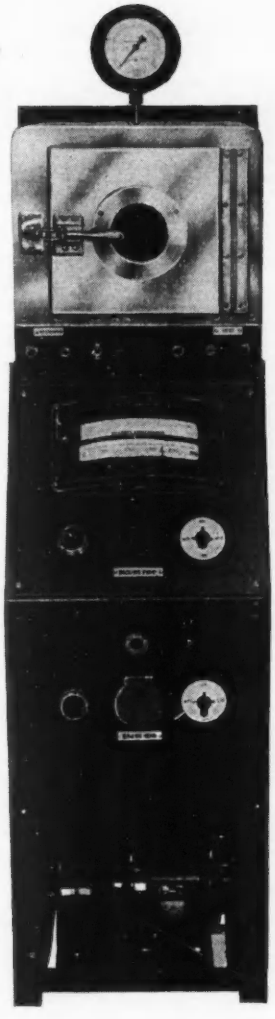
DOUBLE ENDED



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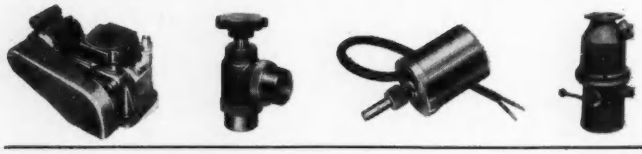

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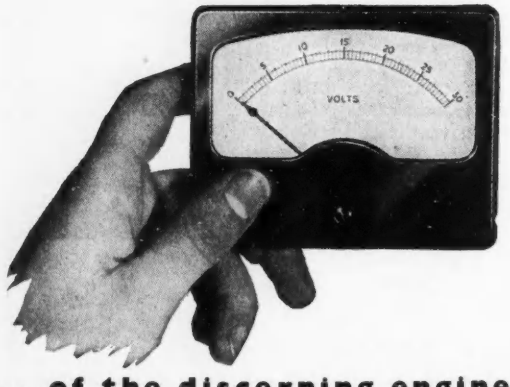

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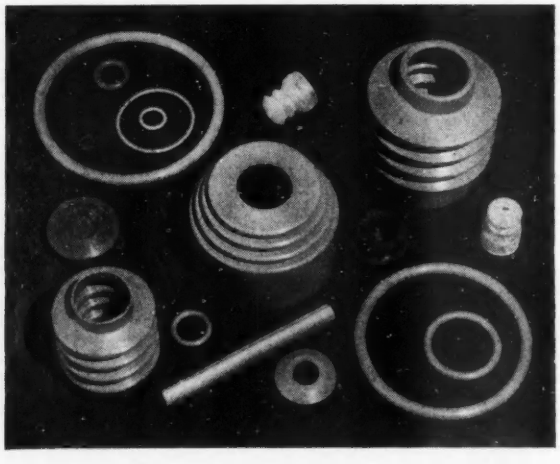

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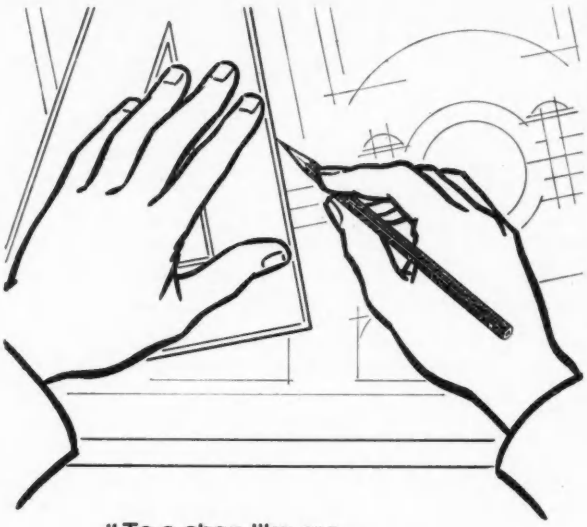

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or nearly but bang on the dot every
time.
The leads must hold their points
and flow smoothly throughout a long line –
no crumbling or 'clinkers' mark you! –
and if I erase a line it must go cleanly –
there's no 'furrow' left in my paper
so you won't find ghost lines in prints
made off my drawings. As a matter of
fact you can tell from a print when it is
my drawing – the print's always first class."

"What pencils do I use?"

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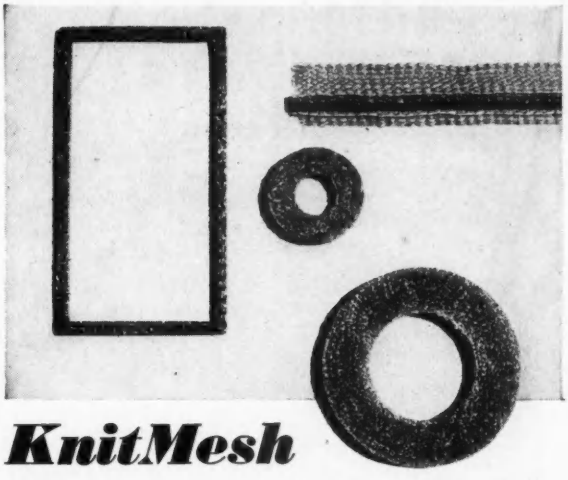
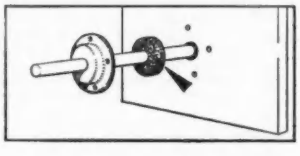


KnitMesh
Electronic R.F. Shields

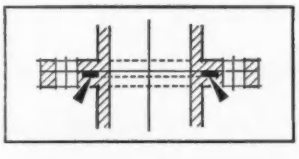
KnitMesh, as its name implies, is a mesh structure of asymmetrical interlocking loops knitted from monel, stainless steel, nickel, silvered copper etc.

When made into electronic R.F. Shields, as weatherstrips, gaskets and spindle glands, the compressibility and resilience of KnitMesh ensure good contact, even when there are surface inequalities. No special machining is therefore required to produce a perfect shield.

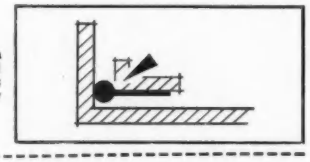
KnitMesh spindle glands of Phosphor-Bronze prevent leakage through spindle holes. The resilience of KnitMesh ensures an excellent seal yet allows the spindle to rotate freely.



KnitMesh flange joint gaskets are made slightly deeper than the grooves in the flange joint which ensures complete metallic contact, flange to flange.



KnitMesh weatherstrip provides a simple method of achieving good contact between sheet metal covers and cabinets, without the necessity of special machining.



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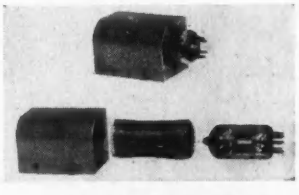
Illustrated is a KnitMesh Monel ultrafine Valve Jacket.



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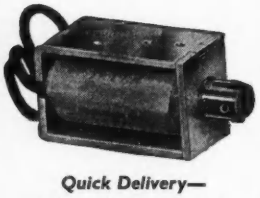

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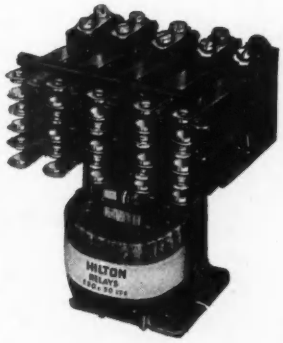

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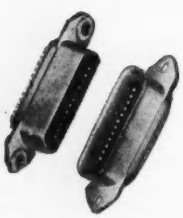

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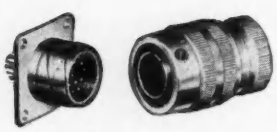

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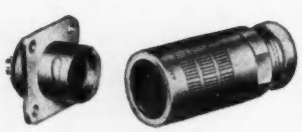

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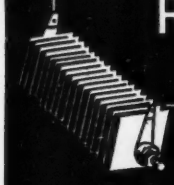

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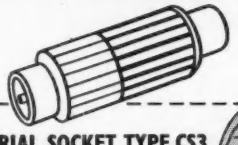

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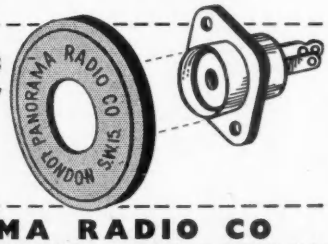

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1959

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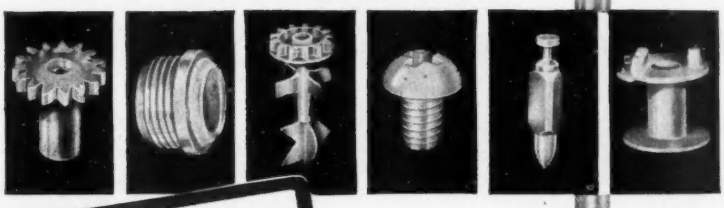

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CLARENDON LABORATORY, University of Oxford, requires an electronic engineer to design and build equipment for a research group. This appointment is for three years only in the first instance. Applicants must possess at least H.N.C. in electrical engineering or equivalent and several years experience. Salary appropriate to age, qualifications and experience. Good holidays and pension scheme. Write giving full details of education and career to the Administrator. W 1248

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INSTITUTE OF OPHTHALMOLOGY (University of London) Judd Street, W.C.1. Electronics Technical Officer required in early 1960. Graduate preferred, to collaborate in medical research and to originate and design equipments. Salary Scale £835—£1,145 per annum. The point on Scale will be determined by age and experience. The successful candidate will be required to join the Federated Superannuation Scheme for Universities. Application, together with the names of two referees, to be sent to the Secretary at the above address by 1st December ,1959. W 1235

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ROYAL ORDNANCE FACTORY, Blackburn, Lancs, requires Assistant Experimental Officers or Experimental Officers for (a) development engineering of variety of electronic equipment (experience in electronic circuit techniques reqd.) or (b) control of accuracy of test and measuring equipment used by large department engaged in design, development and production of electronic equipment (experience in use of electronic test equipment reqd.). Quals. G.C.E. (A.L.), H.N.C., degree or equiv. Salary Ranges: A.E.O. £382 (age 18)—£670 (age 26)—£830. E.O. (min. age 27) £954—£1,166. Opportunities to compete for established (pensionable) posts. Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1., quoting D.511/9A. W 3643

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continued on page 196

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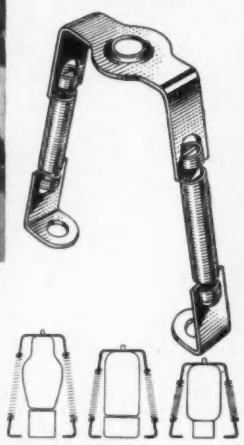


A high-quality, high efficiency retainer made in sizes to R.C.S. 257 and R.C.L. 257. Cadmium plated D.T.D. 904, Passivated D.T.D. 923, connecting springs in stainless steel from EN 58A. Samples and price list on request.

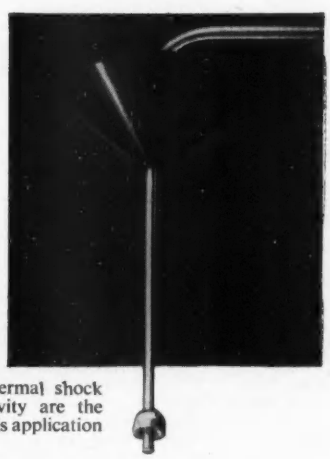
RESISTANCE TO CHEMICAL ATTACK

material answer to design problems

Sintox Technical Advisory Service

This service is freely available without obligations to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blue print if available.

Sintox—an alumina ceramic—is resistant to corrosive atmospheres, solutions and conditions. Sintox is unsurpassed as an electrical insulator, and its properties also include good thermal conductivity and mechanical strength. Its characteristics are such that Sintox can be of service in the Electrical, Electronics, Mechanical and Nuclear Engineering industries.



Edwards Instruments Ltd. selected SINTOX for their 'Telegas' probe assembly for aluminium and aluminium alloy melts. Its qualities of thermal shock resistance and chemical inactivity are the salient features of SINTOX in this application

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SINTOX engineering ceramics

SINTOX IS MANUFACTURED BY **LODGE PLUGS LTD., RUGBY**

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EE 15 255 *for further details*

SITUATIONS VACANT (Cont'd.)

CATHODE RAY OSCILLOSCOPES, an excellent opportunity is open to a young electronic engineer with some experience of C.R.O.'s and a leaning to the sales aspect. A wide variety of interesting problems in the fields of research and industry and involving the application of high class instruments to their solution, await the right man. Apply Nagard Ltd., Avenue Road, Belmont, Surrey. W 1251

DEVELOPMENT ENGINEER of H.N.C. standard with experience in the design of Audio Equipment required in South West London area: some knowledge of relays and methods of remote control would be an advantage. Pension Scheme. Write giving full particulars of experience, qualifications, to Box W 1233.

DEVELOPMENT ENGINEERS (both senior and junior) are required urgently for the design and engineering of single side band H.F. transmitters and receivers. The posts should prove most attractive to ambitious young engineers who are seeking a career with many opportunities for advancement. Vacancies also exist for Engineering Staff to work on other projects of a general communications nature. Applications will be treated as confidential and should be addressed to the Technical Director, Labgear Limited, Willow Place, Cambridge. W 1244

DRAUGHTSMEN. Plessey Nucleonics Ltd., Northampton (The Atomic Energy Unit of the Plessey Group), wish to appoint Electronic Draughtsmen in connection with their development work in atomic measurement and control. This work will absorb imagination, interest and technical ability. An H.N.C. in Electronic Engineering or equivalent qualifications, together with experience in the design of electronic apparatus, are desirable, but those less well qualified will be considered. The posts offer much scope and the remuneration is good. Applications in confidence to the Personnel Manager, Weedon Road, Northampton. W 3627

DYNATRON RADIO LTD. require Electronic Development Engineer. Experience of transistor pulse circuits essential. Good opening with an expanding organization. Apply Personnel Manager, St. Peter's Road, Furze Platt, Maidenhead, Berkshire (Tel.: Maidenhead 5151). W 3631

ELECTRONIC DEVELOPMENT ENGINEERS. Vacancies exist for Research and Development Engineers to work in a well-equipped Laboratory on Transistor Amplifiers, Data Computers and Instrument Servos. Candidates should hold a University Degree or equivalent. Some practical experience is desirable but not essential. Apply in writing, giving full particulars, to S. G. Brown Limited, Shakespeare Street, Watford, Herts. W 1238

ELECTRONIC DEVELOPMENT ENGINEER is required to form a new section in our rapidly expanding Electronics Division. Applicant will be required to work on advanced development of Resistance Welding and Machine Tool Control Systems. The essential qualification is an ability to devise and improve high-grade circuitry, making full use of the latest known valve and transistor techniques, together with a thoroughly practical outlook and appreciation of production aspects. Write, in confidence, giving full details of age, experience, and present salary, to Chief Electronic Engineer, British Federal Welder & Machine Co., Ltd., Castle Mill Works, Dudley. W 1243

ELECTRONIC DEVELOPMENT. To keep pace with an expanding research organization an Electronic Engineer or graduate standard is required. Sound experience in the design and development of varied electronic equipment is essential and as the work is almost entirely concerned with research and production, a high standard of performance and reliability is needed. Applicants who enjoy work of a varied and challenging nature and who are interested in acquiring a broader technical background leading to greater responsibility, are invited to write to the Staff Manager, The Morgan Crucible Co. Ltd., Battersea Church Road, S.W.11. W 3626

ELECTRONIC ENGINEERS. A few vacancies exist for engineers to train as Project Leaders to take complete charge of overseas contracts. Candidates must be single, medically fit, and in the age group 25—29 years. Qualifications: B.Sc., H.N.C. or equivalent. Excellent remuneration and good prospects. Box W 1250.

ELECTRONIC ENGINEERS are required for the design and development of electronic instruments used in industrial testing. (1) One Senior Engineer to take charge of the section dealing with these instruments. (2) One Engineer to work on the use of electronics in electro-chemistry. (3) One Engineer to work on industrial instruments generally. Reply, stating age, qualifications and salary required, to Research Manager, Evershed and Vignoles Limited, Research and Development Laboratories, North Circular Road, N.W.10. W 1219

ELECTRONICS AUTHORS, up-to-date, for Handbook Writing Firm, various locations. Phone Harrow 3036. W 1242

ELECTRONICS RESEARCH LABORATORY STAFF. Senior qualified Electronics Engineers of Degree or Higher National Certificate standard are required for interesting work in connection with a number of projects in the field of electronics, including the application of transistors to television and similar equipment. Applicants must have suitable academic qualifications and experience in laboratory procedure. They will normally be expected to be able to handle a project from its inception to its final conclusion. Box W 340.

ENGINEER. Are you a young man interested in the application of modern techniques to automation non-destructive testing and similar industrial problems? If so, why not write to us giving details of experience, age, and salary level. The person we have in mind is one who is of graduate level and has appropriate practical experience. Applications to K. W. Whittick, Serck Limited, Warwick, Road Birmingham, 11. W 1249

ENGINEERS AND ASSISTANT ENGINEERS are required by a Company in the London Area specializing in Videotape and Telerecording. Applicants should have a good technical background, a knowledge of pulse techniques and electronic servomechanism. Experience of TV broadcasting would be an advantage. Salary range, £997-£1,260. Apply Technical Manager, Alpha Television Services (London) Ltd., 18 Ogle Street, London, W.1. W 1246

ENGINEERS, with some five years' practical experience of radio frequency design work, required for interesting new project in Laboratory situated in South West outskirts of London. Some experience of cables an advantage. Pension Scheme. Write, giving full particulars of experience and salary required, to Box W 1226.

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

G.E.C. APPLIED ELECTRONICS LABORATORIES, Stanmore, Middlesex. Senior Microwave Post. An Honours Graduate with considerable microwave experience is required to lead a microwave measurement section assisting all projects. The work will cover a wide variety of measurement techniques in various frequency bands. There will be scope for investigation of new techniques and development of new measuring equipment. An attractive, four-figure, starting salary will be paid, according to qualifications and experience. This is a responsible post within a progressive salary range. The laboratories provide excellent working conditions in the London area. Please apply to the Staff Manager, quoting Ref. EE/RNA. W 3639

ENGLISH ELECTRONIC ENGINEER with established business in Melbourne seeks contacts in U.K. with view to representation in Australia. Particular interests in instrumentation and components. Write: Box 2365V. P.O. Elizabeth Street, Melbourne, Australia. W 1222

OVERSEAS Oil Exploration Company with world-wide seismic parties, offers permanent career to Electronic Technicians. Maintaining and operating field equipment. Men prepared to accep responsibility and to live in camp conditions Academic qualifications to H.N.C. or equivalent essential, and practical experience in Electronics. National Service completed and an advantage if in relevant work. Home leave every two years. Box W 347.

PLESSEY. Vacancies exist in our Electronics Group for Senior Design Draughtsmen. The work covers a wide range of electronics equipment and test gear and a background of design and production of such equipments or of precision mechanisms would be particularly useful. These vacancies will carry attractive salaries and long term prospects for the right men. The Company operates superannuation and Life assurance schemes as well as Welfare, social and recreational facilities. Applications, which will be treated in strict confidence, should be addressed to the Employment Manager, The Plessey Company Limited, Ilford, Essex. W 3644

PLESSEY NUCLEONICS. An Electronic Engineer is required to work as a member of a team engaged in a study of neutron activation analysis. The work would involve the design of Experimental Electronic Equipment as required for the investigation, the use and maintenance of a Multichannel Pulse Height Analyser, Pulse Counting Systems etc. and, as far as appropriate, a small Electrostatic Proton Accelerator for neutron generation. Applicants should preferably be between 25 and 35 years old with several years experience in electronics. Applications in strictest confidence should be made to Personnel Manager, Plessey Nucleonics Ltd., Weedon Road, Northampton. W 3595

SALES CORRESPONDENT required by Radio and Electrical Component Manufacturer of international repute, situated in West London. Applicants must be experienced in conducting semi-technical correspondence, submitting quotations and generally dealing with customers. Knowledge of electrical/radio industry an advantage but not essential. Superannuation Scheme up to 55 years of age. Write, giving full details of experience, age and salary required, to Personnel Manager, Box SC.1281, A.K. Advg. Ltd., 212a Shaftesbury Avenue, London, W.C.2. W 3628

SUB-MINIATURE ELECTRONIC COMPONENTS. We need Electronic and Mechanical Engineers at all levels to work in this new and developing sphere. There is plenty of scope for originality and thought. The working conditions are good, the atmosphere is friendly, we pay you well and we pension you off if you would rather not die in harness. We could also do with a good Circuit Engineer familiar with transistors. If you are interested, please write or telephone Michael Cohen, B.Sc.(Hons.), Chief Engineer, Ardente Acoustic Laboratories Ltd., 8-12, Minerva Road, North Acton, London, N.W.10. Elgar 3923. W 3634

TECHNICAL AUTHOR. We wish to appoint a Technical Author to take full responsibility for the preparation of instruction manuals and handbooks relating to digital transistorized industrial electronic equipment of advanced design. The Author will become a member of a team working in a very pleasant location in Warwickshire. Applications are invited from suitably qualified men who have had a background in this or a similar field. Replies should be addressed to Personnel Manager, Box W 1247 and should state, age, experience, qualifications etc.

TECHNICAL WRITER:—Duties will include editing quarterly technical journal, preparation of sales application articles and sales publicity on electronic measuring instruments. Good technical knowledge and photographic experience desirable. Salary £800/£1,000 p.a. according to experience. Apply in writing in first instance to Dawe Instruments Ltd., 99/101 Uxbridge Road, Ealing, W.5. W 3645

CLASSIFIED ADVERTISEMENTS
continued on page 198

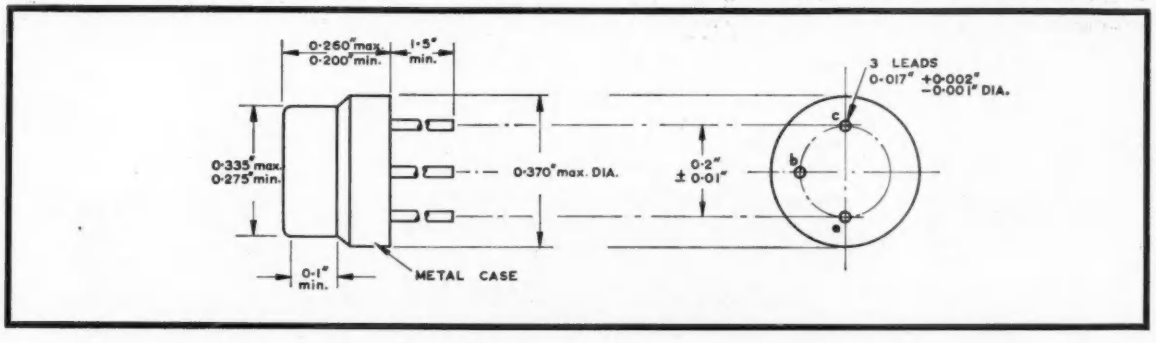
EE 15 256 *for further details*

High speed Switching Transistors

TYPES XA141, XA142 and XA143

These germanium p-n-p drift transistors are specifically designed for use in high speed current switching circuits and feature minimum gain/bandwidth products of 20 Mc/s, 40 Mc/s and 60 Mc/s respectively. Full particulars of these and other Ediswan Mazda semiconductor devices will be sent gladly on request.

If you wish to keep up to date with the latest developments in this field, please ask us to add your name to our semiconductor mailing list.



MAXIMUM RATINGS (Absolute Values)

Collector to base voltage (volts)	− 30
Collector to emitter voltage (volts)	− 29
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Collector current (mA)	−100
Collector dissipation T_{amb}=25°C (mW)	120
Collector dissipation T_{amb}=71°C (mW)	10

PARAMETER CHARACTERISTICS* (T_{amb}=25°C)		**XA141**	**XA142**	**XA143**
Static current amplification at V_{ce}= −7V, I_c= −5mA (h_{FE})	Minimum	20	20	20
	Average	45	45	45
Collector to base capacity (pF)	Average	2	2	2
	Maximum	5	5	5
Gain/bandwidth product (frequency for current gain=1) at V_{ce}= −7V, I_c = −5mA (Mc/s)	Minimum	20	40	60
	Average	30	50	75

**Typical production spreads*

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CRC 15/57

SITUATIONS VACANT (Cont'd.)

TEXAS INSTRUMENTS LIMITED. Due to the planned expansion of this Company attractive and interesting position with great scope for advancement are available for—Electronic Engineers and Electronic Technicians. The vast amount of research, development and testing which we carry out as a leading manufacturer of semiconductors, calls for a highly qualified team to design, construct and maintain the necessary electronic equipment. We are now increasing this team at all levels and the vacancies range from supervisory posts requiring wide experience and the highest qualifications, to other posts requiring at least O.N.C. standard and some experience of similar work. All are monthly salaried positions. Salaries will be based on ability and experience and are reviewed every six months. Applications, giving full details of qualifications and experience and quoting Reference No. 85/6, should be addressed to:—The Personnel Manager, Texas Instruments Limited, Dallas Road, Bedford. W 3646

TRANSFORMER DESIGNER required. Experience in design of Communications and Power Transformers, knowledge of Electronic Circuitry and development. Apply in writing, in first instance, giving age, details of experience and salary required. S.W. Herts area. Box W 1245.

SITUATIONS WANTED

POSITION SOUGHT IN BRIGHTON AREA in Electronics. Considerable experience in Radio and Television servicing with civilian firms. Nine years' airborne and ground radar experience in R.A.F. and R.N.Z.A.F. as N.C.O. Certificates from City & Guilds to Radio III, and references available. Box W 1241.

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EXTRA PRODUCTION FACILITIES: Skilled workers + floor space + expert supervision = extra production facilities for you. See page 176. W 3495

METALWORK. All types cabinets, chassis, racks, etc., to your own specifications. Philpott's Metalworks Ltd., Chapman Street, Loughborough. W 341

PRODUCTION CAPACITY. Lexor Electronics Limited have quantity production capacity available for electronic equipment and microwave assemblies. All inquiries to Allesley Old Road, Coventry. W 345

REMOTE CONTROL EQUIPMENT — Magslips, Selsyns, Synchros, Amplidynes, Metadynes, and many other servo-control components, are supplied to Laboratories and Manufacturers throughout the world by Servo and Electronics Sales Ltd., Technical Dept. 43, High Street, Orpington, Kent (Tel.: Orpington 31066). London Branch: 1 Hopton Parade, Streatham High Road, London, S.W.16 (Tel.: Streatham 6165). Ask for full details of our range now! W 3571

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BARIUM AZIDE, for electronics industry, manufactured by Elgar Research Laboratories Ltd., 25 Salisbury Grove, Mytchett, Aldershot, Hants. Cables: Elgares, Aldershot, England. Telephone: Farnborough (Hants) 2634. W 344

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LEARN RADIO AND ELECTRONICS the New Practical Way! Very latest system of experimenting with and building radio apparatus—"as you learn". Free Brochure from: Dept. EE 10. Radiostructor, 46, Market Place, Reading, Berks. W 3357

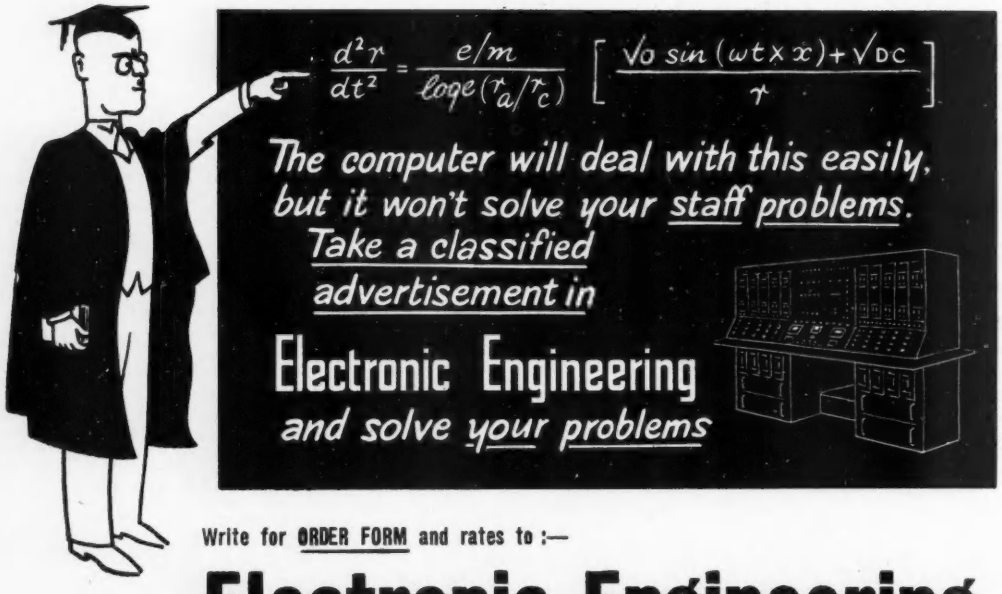
T.V. AND RADIO—A.M.Brit.I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "NO PASS—NO FEE" terms. Over 95 per cent successes. For details of Examination and Home Training Courses (including practical apparatus) in all branches of Radio, T.V. and Electronics, write for 148-page handbook—Free. B.I.E.T. (Dept. 337H), 29 Wright's Lane, London, W.8. W 187

WANTED

COPIES OF ELECTRONIC ENGINEERING for March, August and September, 1958, and February and March, 1959. Good price given for complete issues. Box W 3625.

CAPACITY AVAILABLE

CABLEFORMS AND WIRING. Lexor Electronics Limited have quantity capacity for all types of cableforms, looms, harnesses and equipment wiring. All inquiries to Allesley Old Road, Coventry. W 346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CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

RESEARCH LABORATORIES, LEATHERHEAD, SURREY

ELECTRONICS AND INSTRUMENTS SECTION

Ref. EE/416

The expansion of the Section has created vacancies for **GROUP LEADERS and OTHERS** for work in the following fields:—

(a) **SIMULATORS**—The group will be employed on the development of electrical or electro-mechanical simulators as an aid to studying the performance and control of the national power network, individual generating stations, turbo-alternators, boilers, and other plant. Applicants should be experienced in the design and use of network analysers, etc.

(b) **DATA TRANSMISSION**—The group will be employed on the study and development of digital data transmission and logging techniques and their application to the electricity supply industry in the metering, control and communication fields.

(c) **NUCLEONIC INSTRUMENTS**—The group will be employed on problems of nucleonic and reactor control instrumentation, and in the evolution and development of new types of instrument where reliability is of paramount importance.

(d) **COMMUNICATIONS**—The group will be employed on developing modern telecommunication techniques for the electricity supply industry, including line, carrier, V.H.F. and microwave radio techniques for voice and digital communication, telemetry, remote control and power system protection.

Group Leaders must have a good university degree or equivalent qualification and, as well as being competent electronic engineers well versed in modern techniques, must have had specialist experience of work allied to that of the group for which they wish to be considered. Salaries will be on scales within the range £1,530—£1,985 p.a. according to duties and responsibilities.

Applications for supporting staff will be considered from electronic engineers of at least H.N.C. standard, who have had appropriate experience. Salaries will be on scales within the range £1,195—£1,775 p.a. according to duties and responsibilities.

PROTECTION AND SYNCHRONOUS MACHINE STUDIES GROUP

Ref. EE/414

CHARTERED ELECTRICAL ENGINEERS required for employment of the study of design of new forms of protective gear for use on the Board's network, on investigations into the performance of protective relays, and the behaviour of power networks and plant under transient conditions, involving the use of multi-channel magnetic data recording systems. Research is undertaken into the performance of high voltage switchgear and synchronous machines.

Salaries on scales within one of the following ranges, according to duties and responsibilities:—£1,195—£1,775 p.a. or, up to £1,300 p.a.

Applicants must have a university degree or equivalent qualification, and for the higher posts, previous experience in power system protective relaying and high power transmission is essential.

Applications stating age, qualifications, experience, present position and salary to the Personnel Officer, 24/30, Holborn, London, E.C.1, by 22nd November.

Envelopes should be marked "Confidential" quoting relevant reference number.

Westinghouse

offers

Opportunities in U.S.

for

ENGINEERS & SCIENTISTS

Very high level appointments are open to outstanding engineer-scientists at the Westinghouse Electronic Tube Division in Elmira, New York. This division contains large laboratory and manufacturing facilities and is located in the beautiful Finger Lakes district of New York State.

We are especially interested in personnel with a detailed knowledge of some aspect of microwave tube design. However, we attach more importance to the attainments of the individual than to his exact experience. The men we seek are likely to hold a Ph.D. or be near this level of academic attainment. Also, they should have several years of experience and have acquired some reputation in their field. Salaries will be in the range of $13,000—$17,000 per annum.

Westinghouse gives every encouragement to advance the careers of its scientific staff. Close assoiation exists with the microwave research group at Cornell Univeristy.

We have many English and European engineer-scientists now successfully employed with us. If you are interested in such a career and have the necessary qualifications, please write in strict confidence to Dr. Hilary Moss at the address below. Dr. Moss will be visiting England at the end of December and will then conduct personal interviews with select candidates.

Westinghouse
ELECTRONIC TUBE DIVISION ELMIRA, NEW YORK

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LIMITED

ADVANCEMENT - SECURITY - RESPONSIBILITY AT A.W.A.

Senior Personnel are required to fill responsible openings in the new and challenging field of:

INDUSTRIAL AUTOMATIC CONTROL TELEMETRY

As a result of further expansion of Armstrong Whitworth electronic activities a number of senior staff appointments are open to Electronic and Electromechanical Engineers who wish to work on advanced projects.

Candidates should have a good Honours degree in Physics or Electrical Engineering and at least 5 years experience in electronics.

The type of man we are seeking should be capable of original thought tempered by the ability to drive a project through to a successfully engineered conclusion.

The particular fields are:—

High Speed Transistor Switching and Logic Circuits
Data Transmission
Servo Mechanisms
Electromechanical Devices

These appointments will carry monthly staff status and the salary will be commensurate with the degree of responsibility. Successful applicants will also be eligible for the Hawker Siddeley Group Pension and Life Assurance Scheme, after a qualifying period.

Applications stating age, qualifications and experience should be addressed to:—

Technical Appointments Officer,
SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD.,
Baginton, Nr. Coventry.

Quoting reference: TAO/COMEL/6

DIGITAL COMPUTER ENGINEERS

ENGLISH ELECTRIC has vacancies for a number of

SITE COMPUTER ENGINEERS

For diagnosis of logic and circuitry faults at operational establishments. Successful applicants will, after an initial training course, be required to take up responsible positions at Computer Installations on customer's premises.

Qualifications required are H.N.C. or equivalent with preferably two years' experience in development or maintenance of Computers or other pulse circuitry. During training, special subsistence allowance will be made for any successful applicants who have to live away from home. Attractive salaries would be offered with these positions which are permanent and enjoy the benefit of the English Electric Staff Pension Scheme and qualify, after initial service, for three weeks' annual holiday.

Applications, giving full details of qualifications and experience, should be addressed to Dept. C.P.S., Marconi House, 336-7 Strand, London, W.C.2, quoting reference EE 388A.

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Engineers, having a sound training in pulse techniques and qualifications to H.N.C. standard, are invited to join a group engaged in the design of Radar-type equipments. Experience of designing for radar frequencies is not necessary, although work on radar video systems would be an advantage.

This Company enjoys an international reputation in the synthetic trainer industry and, due to the scope of our activities, both at home and abroad, there are ample prospects of advancement to leadership posts; also opportunities occasionally arise for foreign visits.

Salaries will fully recognize the capabilities of the individual. The positions qualify for membership of the Company's Pension Scheme and nominations for New Town houses will be made where required.

Applications (Quoting Ref. FS/135), giving details of career and education, should be made to:

The Personnel Officer,
REDIFON LTD.,
Gatwick Road, Crawley, Sussex.
Redifon Ltd. is a member of the Rediffusion Group.

ELECTRONICS ENGINEER

A Professional Engineer is required for work on a large **PROTON SYNCHROTRON** being built at Harwell for the **NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE.**

The duties will include the commissioning of electronic and electrical instrumentation and control equipment; assisting scientific staff in the commissioning of high power R.F. equipment, and subsequently, the maintenance of all electronic and control equipment and the installation of modifications.

Applicants should be corporate members of a senior engineering institution or have equivalent qualifications.

Salary: £1,345-£1,800 p.a.

Housing and Superannuation Schemes.

Please send a POST-CARD for details to the Group Recruitment Officer (5032/42), U.K.A.E.A., A.E.R.E., Harwell, Berks.

Plessey

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A young Development Engineer is required by the Chemical and Metallurgical Division, Towcester. He should have Graduate or Higher National qualifications and 2-3 years' experience in a Microwave Development Laboratory or a similar period of production development experience in an allied field.

This is an opportunity to join a rapidly expanding Division situated in a pleasant part of the Midlands within easy reach of London.

Apply to:— The Regional Personnel Manager,
The Plessey Company Limited,
Wood Burcote Way,
Towcester, NORTHAMPTONSHIRE

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The Regentone Group of Companies offer opportunities to engineers and Technical staff in the laboratories of their manufacturing division. There are vacancies at all levels of seniority—all of them provide interesting work and wide scope to men with enthusiasm and who primarily desire to engage in development. Salary scales are imaginative and the organisation is young with a record of rapid expansion.

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This post involves the co-ordination of a team of engineers, and a candidate of sufficient merit will enjoy excellent prospects. Experience of leading a small section would be preferable and applicants should hold at least H.N.C. The salary will be commensurate with the candidates experience and status.

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Engineers with three to four years design experience in some aspect of TV receivers or similar field of circuitry will be needed to fill several posts.

ASSISTANT ENGINEERS
A number of opportunities exist for young engineers with a good basic engineering training, some industrial experience and having a strong inclination to radio and television work.

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Men with a variety of experience are needed. A particular vacancy occurs for a *technical* clerk/writer to assist with administrative work and laboratory records.

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A man with experience of component life testing and approval procedure covering both the Mechanical and Electronic field is needed for this aspect of the Engineering Department's work.

SENIOR TEST EQUIPMENT ENGINEERS
Test equipment engineers are required with some years of experience in designing all forms of electronic test equipment for mass production of radio and television. Specialist experience of sweep generators of TV signal systems would be an advantage.

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These vacancies occur in the television section of the drawing office and call for experience of consumer product engineering. It is not entirely necessary to have worked in the radio industry. The work involves dealing with sheet metal parts, plastic mouldings, small mechanisms, etc.

The company offers good working conditions with up-to-date facilities; superannuation scheme; canteen facilities; and many social activities. Applications should be in writing but further information will be given by telephone.

Write to: TECHNICAL DIRECTOR,
RADIO GRAMOPHONE DEVELOPMENT CO. LTD., EASTERN AVENUE WEST, ROMFORD, ESSEX. TEL.: ROMFORD 45991

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ENGINEERING PHYSICISTS

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Atomic Energy Research

For developing techniques and instruments to study nuclear reactor fuel elements, by non-destructive methods, such as eddy-current and ultrasonic testing.

For design and development of specialized instruments using the techniques of digital computers, automatic data processing, pulse circuitry, and control systems.

Post-graduate training an asset for either post.

Modern fringe benefits—single accommodation in staff residence in Deep River, a planned community on the Ottawa River.

State all particulars in first letter to:—

File 10A
ATOMIC ENERGY OF CANADA LIMITED
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SENIOR TELEVISION DEVELOPMENT ENGINEERS

E. K. COLE LTD., Southend-on-Sea Essex would be pleased to receive applications from suitably qualified men for posts as SENIOR ENGINEERS in their Development Laboratories. Write giving details of qualifications & experience to Personnel Manager.

ELECTRONICS ENGINEERS

Our work on missile development is still expanding and new appointments at all levels will shortly be made at our Hatfield and Stevenage factories. The work covers the guidance, auto-pilot and power systems of missiles, and the development of both flight and ground equipment.

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Electronic and Electrical Engineers required for work on missile ground and airborne systems, covering high-speed turbo-alternators, modern secondary batteries and other low-weight power-producing devices, power measuring equipment and installation work. Applicants should be graduates or engineers with H.N.C. status.

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To work on ground and flight measuring systems associated with ballistic missiles. This covers many types of engineering effort from the design of transducers to the concept of the entire measuring system. Engineers are also required with experience of radio telemetry.

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ELECTRONIC ENGINEERS

(*a*) For circuit development work.

A group of Circuit Engineers to work on advanced missile systems is being set up to develop both flight and ground equipment. Our techniques are quite advanced and practically all circuitry is based on the use of transistors. Engineers are required at degree, and H.N.C. level, with or without previous industrial experience.

(*b*) For production engineering work.

To work on electronic equipment associated with both missile flight and ground systems. Experience in a similar field, particularly with miniaturized equipment and with high quality circuit electronics is desirable.

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THE PERSONNEL MANAGER (REF. 626)

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Applications stating age, experience and qualifications will be treated in the strictest confidence and should be sent to **A. M. Brown, Executive Director (Personnel),**

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quoting reference EE 1597F.

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Owing to expansion in our Development Laboratories vacancies exist for Engineers and Physicists for development work on transistor circuitry, servo-control, microwave equipment or pulse circuits. Candidates should hold a University Degree or equivalent. Recent graduates and those having about two years' post-graduate experience are required.

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or

Labour Manager, Chapelcross Works, Annan, Dumfriesshire, Scotland.

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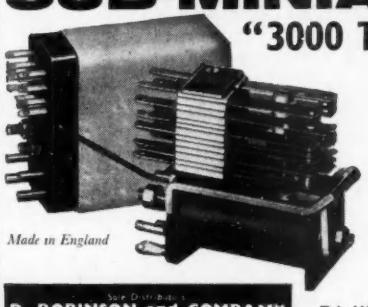

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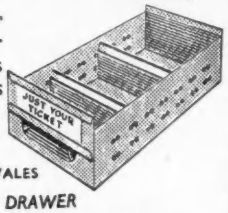

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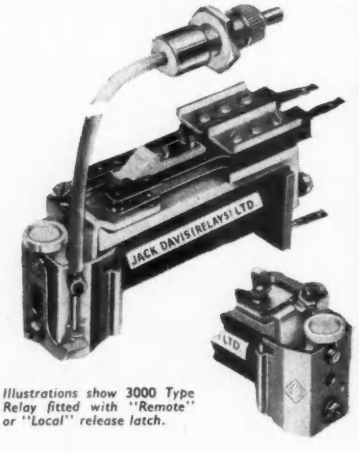

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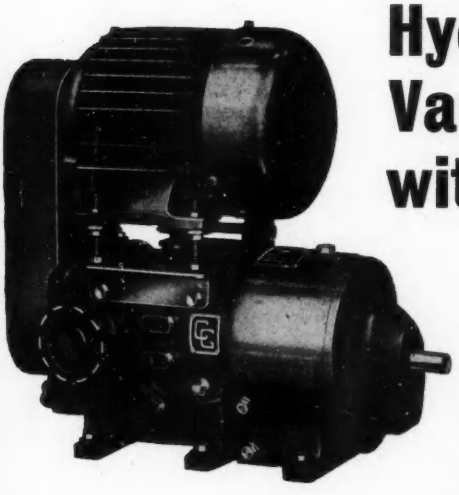

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